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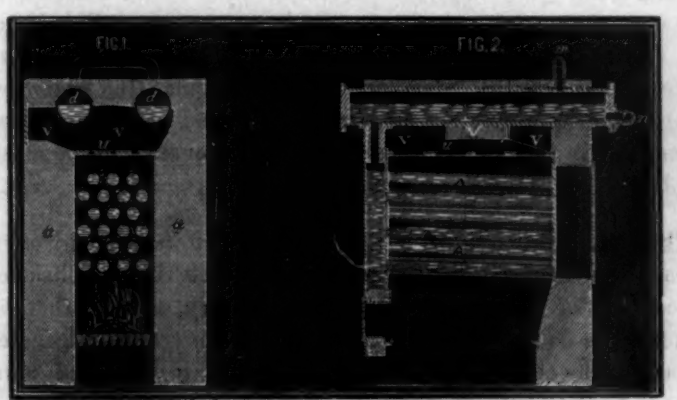
EDITORIAL.

ITEMS AND NOVELTIES.

Ernst Alban's Boiler.—Half a century ago Alban was occupied with the attempt to contrive a tubular boiler for high-pressure steam-engines. He was successful. We give below illustrations and description of it:



"Fig. 2 is a longitudinal section of a boiler and furnace on this principle, the dimensions being given for a boiler of 10-horse power. A A are the generating tubes, having their back ends shut by screwed covers, and their front ends connected by bolts to the back plate of the case B. Each tube is inclined, and has an upper and lower oval communication with the case, as shown.

"I lay the tubes in eight rows or tiers, one over another, and in such wise that the tubes of each row stand over the interstices between those of the row immediately below.

"Fig. 1 is a transverse section through the side-walls *a a* and all the tubes. The lowest row of tubes has the greater number. Space between tubes 1½ inch, and between tube and wall ¾ inch. The case is from 6 to 8 inches deep, 40 to 42 inches high, and 8 to 12 inches wider than the wider rows of tubes, its sides made of cast iron, and front of ½ inch and back of ¾ inch wrought plate, tied by strong bolts to prevent bulging.

"Internal construction is peculiar, to favor circulation of the water and escape of steam. Top end is connected by pipes *g* to the separators and receivers *c* and *d*. These are made of ¼ or ⅜ inch wrought plate iron, provided with strong cast iron end covers, and are not over 18 inches diameter, are connected at back and top by *n* and *m*, water and steam pipes, of equal size—one square inch area to every 25 square feet of heating surface of the tubes.

"The heated gases are detained by the perforated baffle-plate *u*, and afterwards escape, from under *c* and *d*, through the vent *v*.

"A large boiler of this description, which I have already constructed for an engine of 30-horse-power, has two cases, each with 28 boiling-tubes, lying in eight rows one above another; and I have used two separators, with a single receiver between them. This boiler has not only fulfilled, but far exceeded my expectations: the heat is so perfectly applied, the steam production so regular, the water-level so quiet, and the whole so safe, trustworthy and convenient, that its advantages in these respects can seldom be equalled in the most perfect boilers of the ordinary construction." J. H. C.

The Manufacture of Platinum.—As an item worthy of record amongst our mechanical news, we would notice the establishment in our country of a new manufacturing industry, namely, that of the manufacture from the raw material of platinum vessels, wire, etc., for the use of the chemist, and of those engaged in technical pursuits.

For our supply of these materials we have been, until the establishment of this enterprise, entirely dependent upon European makers. The establishment is now, we believe, successfully conducted, in New York, by Mr. H. M. Raynor, and we wish the undertaker of it success.

Steam-Boiler Explosions.—Mr. J. B. Stevens, of the Camden and Amboy Railroad Company, as we learn from the New York *Evening Post*, has commenced a series of experiments on a large scale, that may be expected to throw some light upon the very important subject of steam-boiler explosions.

He has selected four old boilers, recently removed from steamboats, and of ages ranging from 13 up to 25 years, and proposes a series of experiments, commencing with their rupture by hydraulic pressure, and finally exploding them by steam.

He has invited a number of experts and scientific men to witness them, and we are promised a detailed account when they shall have been concluded.

The first meeting took place Sept. 2d, in presence of Mr. C. W. Copeland, and several other experts and builders of New York, and Professor Thurston, of the *Stevens' Institute of Technology*.

The most prominent fact noticed in this first experiment on four boilers was that the stayed surfaces—which are the strongest portions of new boilers, usually—were, in all of these old boilers, the weakest. This is a very valuable piece of engineering information. The boilers will be repaired, and the experiments then resumed.

Floors for Workshops.—Ground floors for large machine-shops are very often made with the plank resting on the surface of the ground, the sleepers to which they are spiked being imbedded in the ground. I have been informed that white pine planks last longer than oak for the same purpose, and it is in fact considered the best wood for the purpose. Some attempts have been made to prevent the decay of such floors, but the question has at once arisen as to the economy in each case. Floors where heavy machinery is erected are subject to very severe wear, and it is asserted that a two-inch white pine floor will wear through in such a place before it has rotted out. On the line of the Georgia Central Railroad floors have been laid in a peculiar manner, which is deserving of note. The ground is levelled off for the floor, and ditches dug to receive the string-pieces or joists; these are coated with melted rosin, before being laid, on the three

sides in contact with the ground. The floor is then laid, with a space of half an inch between the surface of the ground and the under side of the floor planks. After the floor is all down, holes are bored, at intervals of say three feet, over the whole surface, and melted rosin poured into the space below the floor, to entirely separate the planks from the ground. Mr. Wm. M. Wadley, the President of that road, says that floors so laid show no signs of decay, after many years use, in places where the floors usually rotted out in a short time. The Asphalt pavement was adopted in one large shop in this city, but I have not heard how it has stood the test of wear. It was made of spawls from granite mixed with coal tar and asphalt.

In the establishment of Messrs. Wm. Sellers & Co., of this city, the floor upon which the tools rest is made of iron, secured to foundation walls of bricks, while the part of the floor upon which the workmen stand is made of pine plank, readily renewed if it rots out. The asphalt pavement seems to be admirably adapted to the flooring of stables, and in one instance I have seen plank laid upon a floor of asphalt, in the stalls of a modern stable, the proprietor deeming the asphalt composition too hard for the horses' feet. In connection with the decay of floors it may be well to note that reliable builders state that on outside walls the ground floor joists are likely to rot off in about fourteen to fifteen years. My attention was called to this by the sinking of the floors in two houses in West Philadelphia, which had been built about fifteen years. An examination of the case showed that all the joists which had so rotted had been built into the wall at the ends, and the rot had occurred where the timber was excluded from the air and submitted to the moisture of the outside walls. Examining houses in the country which have been erected for at least fifty years, I find the joists still sound, but in no instance have I observed the practice followed of carrying up the cellar wall flush between the joists, as is now the custom in cities. It seems evident that the best plan is to make an offset in the cellar wall to receive the joists, and, if the space between the joists is to be filled up for the looks, to let the filling in fall back of the face of the wall, below the joists, say one or two inches. COLEMAN SELLERS.

Errata to Article on a Ship-Channel across Cape Cod.

U. S. ENGINEER'S OFFICE, *Oswego, N. Y., Aug.* 12, 1871.

* * * * * * * * *

Owing to my absence from my office in Boston, and a misapprehension on the part of the person left in charge of the office, I did not

receive the proof-sheets of the article on a Ship-Channel across Cape Cod, which appeared in the June and July numbers of the *Journal*. The result was that a number of typographical errors appeared in the article, which are herewith corrected:

In foot-note to page 390, vol. lxi, the last sentence should not be included in the quotation. It should read: * * * relation of these basins."—Mass. Pub. Doc. No. 41, 1863. Not to underestimate, &c.

In 3d foot-note to page 388, read "Hagen," instead of "Hagar."

On page 42, vol. lxii, 1st line, instead of "highest," read "lightest."

" " 4th line, supply after the word city, "converting the portion of the river opposite the city."

Page 42, 15th line, instead of "omitting," read "uniting."

In first note to page 45, read "Harwich," instead of "Harurch."

JOS. P. FRIZELL.

Detroit River Tunnel.—We learn that the work on the Detroit River Tunnel will be commenced at once, and that Mr. Cheesebrough, the already famous engineer, will take charge of the work.

The plan of the tunnel contemplates a series of three cylindrical tunnels. Two of these will be for railroad purposes, each being 18½ feet interior diameter. They will be parallel, and 50 feet apart. This plan is deemed preferable to a single tunnel with double tracks, both on account of less liability of accident to trains and delay from obstructions, and on accouut of the strength and economy of the structure. The third tunnel will run under the river, and below and midway between the other two. It is for drainage purposes only, and will have an interior diameter of five feet. The third tunnel will be constructed first, in order to drain the other two tunnels as the work progresses. It is expected that the building of the lower tunnel will determine the feasibility of the entire project, and this will be completed before work is undertaken on the railroad tunnel.

Work will be commenced on the grounds of the Detroit and Milwaukie Railroad Company. Here a shaft, ten feet in diameter, will be sunk to the required depth, and excavating under the bed of the river will proceed from that point. As the excavating proceeds, a shell of brick masonry will be constructed in a permanent manner. By the time that the middle of the river is reached, operations of a similar character will be commenced on the other side of the river, and the work will proceed from both directions. If the first tunnel should

prove successful, the work upon the others will be immediately begun. The engineer estimates that a year and a half to two years will be required to complete the work. The entire length of the tunnel, not including approaches, will be about two miles, and its estimated cost nearly $3,000,000.

The New York Docks.—It is stated that the work upon the rebuilding of the docks of that city is in progress. The plan, if carried out in accordance with announcement, will secure to the city a wharf-line of thirty-seven miles, and a pier area of more than five million square feet. It is designed to build a river-wall of solid masonry along the North and East Rivers, from which, at regular distances, piers, none less than sixty and many one hundred feet in width, are to be built at right-angles.

Dies for Thread-cutting.—We are informed by the foreman of a large establishment in this city for making wrought-iron gas-pipe, that the dies for threading the ends of the pipe should be made with more material than is absolutely necessary on the score of strength, in order that the surplus metal may aid in conducting away the heat. He says that in cutting the maximum number of ends without sharpening the dies, with a solid die made of the least possible amount of metal consistent with strength, as compared with one made of, say, four times the amount of metal, the large die will cut four or five thousand ends, while the small one will be dull after cutting fifteen hundred. The cutting edges are the same in both cases.

C. S.

East River Bridge.—For the last five weeks operations have been steadily going on at the New York terminus of the East River Bridge, preparatory to placing the caisson and planting the masonry. The locality adjoins the Roosevelt Street Ferry, and presents a busy scene. About 100 men, including dock-builders and ship-carpenters, are constantly at work there under the supervision of the engineer in charge, and several divers and borers are constantly employed. At the northern end of the site a new pier has been built, and inclosed with the most solid plank, forming a perfect breakwater. This diverts the tremendous current, and gives a space of still water for submarine operations. The entire pier, which is 400 by 100 feet in extent, has been covered over in the most substantial manner, to afford conveniences for the heavy machinery, lumber, &c., to be used upon the structure. Where the caisson is to be sunk the bed of the

river has been dredged to the depth of thirty-seven feet. About twenty feet of mud and all sorts of refuse has been taken out, and several valuable and antique relics have been found, including arms, coins, pieces of ship furniture and a part of a human skull. A boring apparatus has penetrated to the depth of sixty-six feet below high-water mark, and at this point a layer of quicksand six feet in depth has been reached. It has been found that the rock strata eighty-three feet down is of a nearly uniform grade, and to this level the caisson is to be sunk. This will be a more difficult undertaking than the placing of the Brooklyn caisson, owing to the facts that this one is four feet larger than that was, and that the current will interpose a much greater opposition. The plan is to float the caisson down from its present mooring, at the foot of Sixth street, to its permanent location, Monday Sept. 11th. About eight weeks more of labor will then be required to complete the preparations for sinking it, and from that time the work of building the tower will be rapidly pushed forward.

Boiler Legislation.—At its last session, a law was passed by Congress, the provisions of which are now being carried out with commendable promptness, regulating certain matters in relation to steam boilers used on passenger boats and cars. One of the most important of these provisions declares that it shall be the duty of their proprietors to attach to every boiler used for this purpose, an automatic indicating gauge—approved by Government—which gauge shall be placed in such a position that it may be inspected by every passenger. The indicator is made to trace upon a rolling paper the various degrees of steam pressure existing in the boiler. The whole apparatus is enclosed in a locked case, the key of which is in possession of the government inspector, who has only to examine the record on the paper to decide positively as to whether or not the pressure allowed in each particular case, (determined by periodical inspection), has been at any time exceeded.

It is only by forcing the universal adoption of a rule as excellent as this, and which has been so often recommended, that the day of "unsolved mysteries" in the history of boiler explosions can fairly be expected to terminate.

Ammonia as a Motor.—For some months vague items have been circulated in the columns of the public press, announcing the news that the utilization of liquified ammonia as a motor had been

successfully accomplished by an inventor in New Orleans, La. It now appears that these detached accounts have some foundation in fact. A correspondent of the "Iron Age" forwards to the editors of that excellent journal, a report of a committee of engineers appointed to investigate the practicability of the plan in question. Of this committee, it is stated, General Beauregard was chairman, and the report was a favorable one.

The mechanical details are too complex to be here detailed, but the theory of the operation is essentially that of the ice-machine operated by volatile liquids; though the cold utilized in the latter case is to be obviated in the former, by a suitable arrangement of parts, the energetic absorption of the evaporating liquid by water being here applied to the production of motion in an engine. The car to which the ammoniacal engine was attached, has, we are told, already made 300 successful trips, at a cost which compares very favorably with the animal motor it replaces.

A New Method for the Observation of Time.—At the last meeting of the American Association for the Advancement of Science, Prof. Hilgard, of the U. S Coast Survey, developed a new use of the zenith telescope or equal altitude instrument, so successfully employed for the determination of latitude, by applying it to the observation of time. According to this method, a couple of stars having nearly the same declination, but differing some hours in right ascension, are observed on opposite sides of the same meridian; preferably in the prime vertical, by noting the time when they attain the same altitude.

If the two stars had precisely the same declination, it is obvious that the simple mean of the observed times would correspond to the mean of their right ascensions. The correction for the small difference in declination, as well as the local correction, are obtained by simple differential formulæ.

The practical usefulness of this method of "equal altitudes" depends upon the fact that so many stars have now been accurately determined in position, as to render the selection of pairs fulfilling the required conditions, either for the observation of latitude or time, an easy matter.

Meteorological.—Prof. Henry, of the Smithsonian Institution, in an interesting address upon the methods of observation, and the results of the meteorological observers engaged by the Institution, lately

remarked upon the popularly accepted belief, that the removal of forests, and, generally speaking, cultivation tended to diminish the amount of rain-fall. He expressed the opinion that the obversations of the Institution, which extend over a period of twenty years, have as yet failed to establish a theory of this kind, and that it must therefore be regarded as a gratuitous hypothesis unsubstantiated by fact.

New Applications of Electricity.—Our exchanges inform us of several new applications of this agent in the mechanic arts. One of them has for its object, the production of an engraving upon metal plates. Another is for the unexpected purpose of filling locomotive tanks with water, which we are informed is actually in use on the Chicago, Burlington and Quincy Railroad. We may mention in the same connection, that the same agent has been employed, and very successfully, for the filling of teeth, an application more surprising perhaps than any hitherto accomplished.

The inventor, Dr. Bonwill of this city, presented, at a late meeting of the Franklin Institute, a device for this purpose which attracted great attention. It consisted of an electro-magnet, of a horse-shoe form, furnished with an armature. Suitably attached to the magnet is the plugging tool. A discontinuous current passing through the apparatus, from a battery of several cells, gives a series of blows from the mallet with great rapidity, which, striking upon the upper end of the plugging tool before reaching the face of the magnet, drives the tool forward a fraction of an inch at every blow, the strength of which can be regulated at the will of the operator. The work of dentistry is hereby claimed to be greatly lessened, and the time of an operation considerably shortened.

New application of the Microscope.—The announcement is going the rounds of our contemporary scientific press that the different qualities of iron and steel can readily be determined with the aid of this instrument. The crystals appear beneath the microscope as double pyramids, and the height of these pyramids relatively to the dimensions of their bases is different for the different qualities of the metal; the disposition of the crystals is also stated to be an important factor. Whether this declaration, which is due to Mr. Schott, will prove of practical importance remains to be seen.

Prevention vs. Cure.—Perhaps the latest public demonstrations of the value of the well known adage is afforded by the appointment of an Examining Board, by the authorities of a neighboring city, to

weed out from the business (termed elsewhere profession) of dispensing pharmaceutists those who are found ignorant of a necessary knowledge of drugs and medicines.

Where so much depends upon the education and intelligence of a class in the community, it is surely unnecessary to argue the point, that a system of legislation under which incompetents may freely exercise dangerous liberties, is highly incomplete. It is scarcely necessary to add that the plan which is found to be so efficient and essential in more thickly populated countries than our own—the establishment of educational institutions under State supervision—would afford ample protection to him who has thoroughly prepared himself for his profession; while it would as effectually prevent one who is unfit, by reason of ignorance or incompetency, from competing with the former, and what is of infinitely greater importance, from imperilling the lives of his fellows.

Fluorescence.—In Repert. der Physik., E. Lommel has an interesting discussion of the subject of fluorescence, from which we extract the following:

"The fluorescent liquid used in the experiments is an alcoholic solution of an aniline color, Magdala red (Rose de Magdala), which fluoresces with a brilliant orange-yellow. To observe the behavior of this substance under the different rays of the spectrum, the light from a vertical slit is passed through a prism whose refracting edge is also vertical, and the rays thus dispersed thrown down on the liquid by a totally reflecting prism. Fluorescence begins between C and D, and continues without interruption in the same orange-yellow shade beyond the violet; it is strongest in the greenish-yellow beyond D and has two other less luminous maxima in the green been E and *b* and in the violet. On condensing this fluorescing spectrum, by means of a cylindrical lens, into a narrow band, and examining with a spectroscope, the spectrum, thus derived from the fluorescing one, contains red, orange, yellow and greenish-yellow. The scale of the spectroscope employed was such that the Frauenhofer lines had the positions:

B	25	F	90
C	34	G	137
D	50	H	162
E	71		

"On this scale fluorescence begins at 35, attains a maximum a little before D, and disappears at 53.

"When monochromatic yellow light, such as that derived from incandescent sodium vapor, is thrown in the solution, the spectrum of fluorescence has the same limits (35—53). The monochromatic yellow light has therefore produced not only red and orange-yellow rays of less refrangibility, but also yellow of the same and greenish-yellow of greater refrangibility.

"When the solution of Magdala red is placed in the red rays obtained by passing sunlight through suboxide of copper glass, it fluoresces in this red light with its usual orange-yellow, and its spectrum again extends from 35 to 53, while the red light extends to 48 only. This red light has therefore produced not only red rays, but also yellow and green-yellow of greater refrangibility. Stokes' law, that the refrangibility of the exciting rays is always the upper limit of refrangibility in the excited rays, is in this case untenable, and the very common opinion, that fluorescence is an action, in which refrangible rays are converted into less refrangible ones, appears erroneous.

"As all the exciting rays are absorbed by the fluorescing substance, absorption becomes an important point in investigating fluorescence. A concentrated dark red solution, which has only a superficial dirty orange-yellow fluorescence, transmits red only to 35. From 36 there is complete darkness. A weaker solution transmits red to 46, then faint absorption to 48; from 48 to 98 complete darkness, after which there is a faint violet. A very faint rose-red solution, which, however, fluoresces strongly orange, shows a faint absorption band between 53 and 60; between E and *b* a darker band, and then a subdued blue and violet almost to H. On comparing these results with the foregoing, it appears that the spectrum of fluorescence begins at the same point where absorption begins in concentrated solution, and that to every maximum of absorption there corresponds a maximum of fluorescence."

The Introduction of the Metrical System.—On the second day of its meeting, the attention of the American Association was directed, by Prof. Hilgard, of the U. S. Coast Survey, to the progress which had been made by the Survey, under instruction of Congress, to introduce the metrical system into general use in our country. Prof. H. stated that a special commission had visited Paris on this business, and had brought with it the standard of the French system, one of them being one of the original standard bases (the meter) established by the first French commission, which fixed the metrical system.

The standards secured by the commission are a meter bar of gilded brass and one of platinum. From these the commission have made fifty (50) sets, or copies, with all possible precaution, for distribution amongst the several States.

The bearings of the question were fully discussed, the objections being mainly the great inconvenience and pecuniary loss which would possibly be suffered by the large machine shops, whose standards of measurement would necessarily have to be altered by any legalized alteration of the standard.

In answer to this objection the cases of France and Holland were offered, which States had adopted the system from its obvious advantages, it being assumed that the change would be a gradual and not a sudden one.

A New Bronze.—We learn from a recent copy of the *Polytechnisches Journal*, that some investigators have succeeded in producing a new alloy which possesses peculiar advantages over others, for a number of processes in the arts. The peculiarity of the new compounds consists in the fact that it contains phosphorus as an ingredient. The authors have not divulged the details of the plan by which they succeed in introducing this substance into combination. It is used with copper, or with copper and tin, either with or without the addition of zinc. The alloy produced is said to be peculiarly adapted for the construction of certain portions of machinery, as also for gun-barrels.

It seems, from an editorial note from Dr. Dingler, that the attempt to introduce phosphorous into the composition of several common alloys had been repeatedly made, but without success. The well-marked influence which its presence, in even trifling quantity, exerts upon the physical properties of irons, would seem to be the ground upon which the repeated efforts to utilize its presumable influence on other metals, is based; and there can be very little doubt but that the subject is worthy of the most careful attention of workers in metal.

New Fire-test for Petroleum.—At the Indianapolis meeting of the American Association, Dr. Van der Weyde described a plan for determining the burning-point of petroleum oils without the use of fire, which is worthy of attention, as well from its simplicity and accuracy as from its safety.

It is well known that the amount of combustible vapor evolved by

a sample of these oils at a given temperature, depends, not upon its gravity, but upon its quality. Two oils (for example) of the same gravity need not necessarily evolve at 110° Fahr. (the accepted standard temperature for the fire-test) the same amount of vapor; since one of them might be a mixture of oils lighter and heavier, the mean specific gravity of which might bring them to the same weight as the other. The amount of vapor given off by the two samples at the same temperature would, however, be very different, since the one adulterated with the light oils would evolve considerably more than the simple heavy oil of the other sample. The author has taken advantage of this fact, and simply measures the amount of vapor given off by the oil at the standard temperature, which is compared with computed or experimentally established quantities, and from this is able to announce the quality of the oil.

A graduated glass-tube, open below, is filled with the oil, and immersed in a vessel of water of the temperature of 110° F., and the amount of vapor given off is read from the graduation. The avoidance of the danger from fire, and the small liability to error, afford strong recommendations for its use.

Determination of Combined Carbon.—We present herewith a brief abstract of a very interesting paper read before the Association by Edward R. Taylor, S.B., upon an improved method of determining the combined carbon in steel. The improvement is upon the well-known method of Eggertz, and the paper is reserved for subsequent illustration and publication in full.

The balance, most ingeniously constructed of a thread of glass, with a cup of the same material attached to a hook on its end, serves to weigh the drillings in an expeditious manner. The weighed substance is then treated in a glass tube with nitric acid, and is placed in a bath kept at the temperature of 130° C.; here the action is completed in 20 minutes, and the carbon determined by comparison of the color of the solution with a series of standard colors.

Inauguration of the Mont Cenis Tunnel.—The official inauguration of the Mont Cenis Tunnel took place on September 17th, all the arrangements having been carried out with great *eclat*. A train of twenty-two carriages, occupied by various dignitaries, including representatives of France and Italy, the directing engineers of the work, and many other officials, was run safely through the tunnel, occupying about twenty minutes in the passage.

Congratulatory telegrams were received from various governments, complimenting the directors upon the successful termination of the gigantic enterprise.

Simple Process for Nickel-Plating.*—Prof. F. Stolba communicates a plan for nickel-plating, by the action of zinc upon salts of nickel in the presence of chloride of zinc and the metal to be coated. By this process, the author informs us, he has succeeded in plating objects of wrought and cast-iron, steel, copper, brass, zinc and lead. It is only necessary that the size of the objects should permit them to be covered entirely by the plating liquid, and that their surfaces should be free from rust or grease. The following is the *modus operandi:*

A quantity of concentrated chloride of zinc solution is placed in a cleaned metallic vessel, and to this is added an equal volume of water. This is heated to boiling, aad hydrochloric acid is added, drop by drop, until the precipitate which had formed on adding water has disappeared. A small quantity of zinc powder is now added, which produces a zinc coating on the metal as far as the liquid extends. Enough of the nickel salt (the chloride or sulphate answer equally well) is now introduced to color the liquid distinctly green; the objects to be plated are placed in it, together with some zinc clippings, and the liquid is brought to boiling.

The nickel is very soon precipitated, and in course of fifteen minutes, if the work has been properly performed, the objects will be found completely coated. The coating will vary in lustre with the character of the metallic surface; where this is polished the plating will be likewise lustrous, and *vice versa.*

Varying the process by the addition of a salt of cobalt, instead of nickel, will afford a cobalt plating, which, the author informs us, is steel grey in color, less lustrous and more liable to tarnish than the nickel.

Occlusion of Hydrogen by Nickel.—Prof. Böttger informs us† of an investigation conducted by him with the view of verifying the announcement made some months ago by Raoult, viz., that porous nickel possessed the property, like palladium, of occluding nascent hydrogen. The verification was successful, as the following abstract of his paper will show:

* Dingler's Polytechnisches Journal, cci, 145.

† Böttger's Polytech. Notizblatt, 1871, 10.

"The statement of the first observer was to the effect that nickel, when used as a negative electrode in acidified water, for 12 hours, would be found to have absorbed 165 times its volume of this gas; and that, detached from the galvanic circuit and plunged in water, the absorbed gas would be slowly evolved in the course of a few days."

Prof. B. varied the experiment by placing the porous mass in ether, and observed that for many hours afterwards numerous gas bubbles ascended through the liquid. He also succeeded in bringing about the reduction of a salt of ferric oxide, by allowing the metal to liberate its gas in the solution.

This slow evolution of the absorbed hydrogen seems to be a peculiarity not possessed (according to the author's observation) in the well-known instance of Palladium, the behavior of the two metals in this regard being strongly contrasted. The latter metal will absorb five times as much of the gas as the nickel, and when removed from the circuit, and quickly dried, will give it out again with great rapidity, heating the metal thereby so strongly that gun-cotton loosely wrapped about it will explode.

Determination of Heating-Power of Coals or other combustibles.—At the last meeting of the Franklin Institute the Secretary mentioned, in his monthly report, the process of Thompson as being worthy of the special attention of analysts, from its accuracy and simplicity.

The apparatus is extremely simple in construction, consisting of a cylindrical vessel of copper, punctured below with numerous small holes, and to the top of which is attached a hollow tube of the same material, closed with a stop-cock; a small vessel of the same form to contain the materials, and a basal piece in which to fit it. The operation is as follows: A weighed portion of the finely powdered combustible is intimately mixed in the mortar with a certain quantity of nitrate and chlorate of potassa. This mixture is next placed in the small copper cylinder, and ignited with a fuse of known dimensions. Before the combustion takes place the outer cylinder is slid down over it, being held there by springs attached to the basal piece, and the whole contrivance is plunged into a vessel containing a known quantity of water, whose temperature has been previously carefully ascertained. The combustion soon sets in, and continues with vigor until the material has burned completely out. The experiment is an exceedingly striking one to look upon. Tongues of flame shoot from

the punctured openings beneath the liquid, and thick clouds of smoke, filling the upper portion of the jar, pour down over its sides like water. The instant the combustion has ceased the stop-cock in the tube is turned, and the water allowed to enter the air-chamber, to cool down the heated interior. The operation is now concluded by again observing the temperature of the water.

From these data it is easy to calculate the results, making due allowance for the slight loss occasioned by the impossibilitity of bringing the apparatus back to its first temperature (owing to the increased temperature of the water) and the very small losses by radiation and conduction, all of which are readily susceptible of measurement.

A Photo-lithographic Process with Caoutchouc.*—G. Wharton Simpson has communicated to a photographic cotemporary, the informatian that an investigator (Swan), had found caoutchouc to be sensitive to light in a peculiar manner. A film of caoutchouc attached to a lithographic stone and exposed to the light, gives to the stone the property of taking up greasy inks upon the lighted portions. Upon this fact, the author tells us, a lithographic process is founded, by taking a sheet and coating it with a layer of caoutchouc dissolved in benzole, exposing this beneath the negative and transferring to the stone.

Curious Adulteration of Analine Colors.† Dr. M. Reimann mentions an adulteration of an aniline brown which, from the difficulty of its detection, is certainly to be regarded as ingenious. The samples offered nothing suspicious to the eye, except the irregularity in size of its particles. By repeatedly boiling the larger pieces in alcohol until the liquid was no longer colored, it was found that they had not decreased in size nor altered their shape, from which a simple test showed that they were composed of triturated wood or brown-coal; but so strongly saturated with a solution of the coloring matter that there was nothing in their appearance to distinguish them from the genuine material.

Porous Iron as a Purifier.‡—Attention has recently been directed to the energetic action which spongy iron exerts upon organic matters impurifying waters. It is asserted that impure water may be made potable with remarkable rapidity, by the use of a filterer properly constructed of this material.

* Berliner Photograph. Mittheilungen, 1871, 307.
† Dingler's Polytech. Jour., cxcix, 514.
‡ Archiv der Pharmacie, cxcv, 273.

Civil and Mechanical Engineering.

THE "WESTFIELD" STEAM BOILER EXPLOSION.

PROFESSOR R. H. THURSTON'S INVESTIGATION AND REPORT.

The steam ferry-boat "Westfield," is one of three boats which have formed one of the regular lines between New York and Staten Island.

The "Westfield" made her noon trip up from the Island to the city on Sunday, July 30th, and while lying in the New York slip her boiler exploded, causing the death of about one hundred persons and the wounding of as many more.

When the case came before the coroner, Mr. P. H. Keenan, for action, he applied to Professor R. H. Thurston of the *Stevens' Institute of Technology*, requesting him to make an examination of the exploded boiler and of its effects, and to witness the testing, by a Board of Experts appointed by the Government, of the steam gauge and safety valves, and of the iron of which the Westfield's boiler was composed. He further requested Prof. T. to assist him in the examination of experts upon the witness stand.

We give the more generally interesting portions of the report and the accompanying sketches.

STEVENS' INSTITUTE OF TECHNOLOGY,
Hoboken, N. J., Aug. 11th, 1871.

Sir:—As requested by you, I have made a careful examination of the exploded boiler of the steam ferry-boat "Westfield," as it now lies at the foot of 12th street, East River. I have examined the piece of iron carried to Police Headquarters.

I have also witnessed, with the Board of Experts appointed by Supervising Inspector, Addison Low, the testing of the steam gauge of the "Westfield," and of both her ordinary and the so-called, "Government" or "Lock-up" safety valves.

I have, in company with the same Board of Experts, witnessed the testing of pieces of iron taken from the ruptured sheets of the boiler.

Having thus fully complied with my instructions, I would offer the following report:

In view of the fact that you have requested me to assist you in the examination of experts on the witness stand, I have deemed it proper to furnish a simple statement of observed facts and of logical inferences from those facts, together with such well known scientific and

professional information, and such simple calculations as may throw light upon the subject.

I would avoid the expression of merely individual or of disputed opinions.

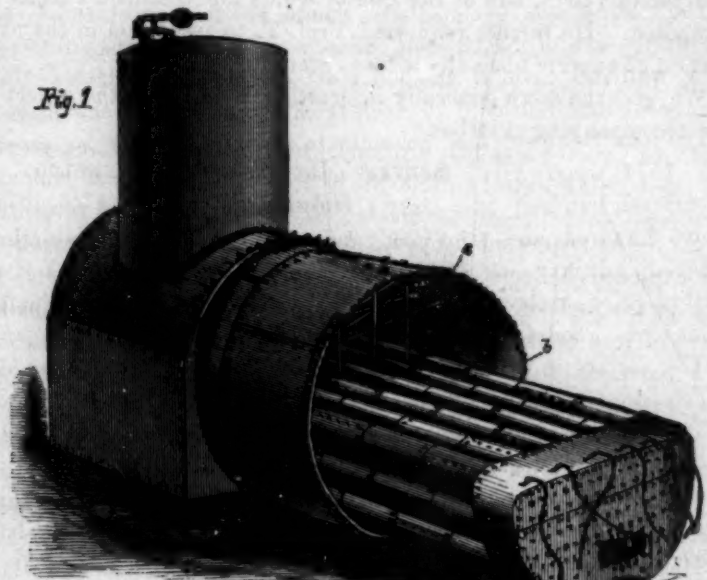
On visiting the "Westfield," I found the vessel lying at the foot of 12th street, East River, in almost precisely the condition in which she was left by the explosion.

The explosion does not seem to have been one of unusual violence. Far more striking effects have been frequently produced by the explosion of much smaller boilers.

The main deck, forward of the engine, is completely torn up, and the largest portion of it carried forward and lodged upon the bow of the boat, where it covers, and is partly supported by, a part of the "shell," or outer portion of the boiler, which has been thrown directly into the "eyes" of the vessel.

The boiler is of a very usual form, as represented in Fig. 1*, and is known as a "Marine return-flue boiler."

Fig. 1



*We are indebted to the enterprising publisher of our contemporary, the *Iron Age*, for the use of this carefully made engraving of the boiler after the explosion.

The diameter of its shell—the cylindrical part now ruptured—is ten (10) feet; its thickness, No. 2 iron, twenty-eight hundredths (0.28) inch. The lower third has its girth seams double rivetted.

The "fire-box" is of iron, three-eights ($\frac{3}{8}$) inch thick, and from the three furnaces the flame and gases pass to the back end of the boiler through two (2) flues of twenty (20) inches diameter, and eight (8) flues of fourteen (14) inches diameter. The former are of No. 4 iron, twenty-four hundredths (0·24) inch, and the latter of No. 6 iron, two-tenths (0·2) inch thick.

From these flues the flame issues into the back connection where it rises and enters six (6) sixteen (16) inch flues, through which it returns to the fire-box end of the boiler, and then rises through a forty-six (46) inch flue in the steam chimney. The steam chimney itself is about seventy-six (76) inches in diameter and twelve (12) feet high.

The sixteen (16) inch flues are of No. 6 iron, two-tenths (0·2) of an inch thick, and the steam chimney of iron, five-sixteenths ($\frac{5}{16}$) thick.

The "flue-sheets"—*i. e.*, those sheets which support the ends of the flues,—are of No. 2 iron, twenty-eight hundredths (0·28) inch thick, while all parts of the boiler not mentioned are of No. 3 iron, twenty-six hundredths (0·26) inch thick.

The total "fire surface" amounts to fifteen hundred and seventy-four (1574) square feet; the total area of cross section of main flues is eighteen hundred and sixty (1860) square inches, of return flues twelve hundred and six (1206) and of steam chimney flue sixteen hundred and sixty-two (1662) square inches.

Of the fire surface above described, rather more than one-half, or about eight hundred (800) square feet is, by law, considered effective heating surface in calculating area of safety valves.

The boiler is broken into three parts.

The first, and by far the largest part, consists of the furnaces, steam chimney and flues, with a single course of the shell; the second consists of two courses of the outside of the shell next the back head, together with that head, to which they are still attached; the third piece consists of a single complete course from the middle of the cylindrical shell, which has been separated at one of its longitudinal seams, partially straightened out and flung against the bottom and side of the boat.

This last piece lies directly opposite its original position in the boiler before the explosion, while the first and second pieces have gone in opposite directions, the former now lying several feet nearer

the engine than when *in situ*, and against the timbers of the "gallows-frame," while the latter piece has been thrown fifty feet forward into the bow of the boat, where it now lies, torn and distorted.

The longitudinal seam, along which piece number three separated, will be shown you, and the deep score or "channel," cutting nearly through in many places, and presenting every evidence of being an old flaw, will be pointed out. The mark made by a chisel in chipping, and that of the caulking tool, may be seen and indicate the probable initiative cause of the flaw.

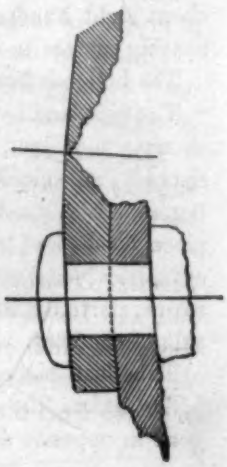
Measuring from the man-hole—which is found in this sheet, and which was originally at the top of the boiler,—to the fractured seam, shows it to have been upon the right hand side, facing forward, and about three feet below the middle line of the boiler.

The position of this piece indicates, evidently, that it was thrown off *first*, as otherwise it must have been dragged either forward by piece number two, had the girth or vertical seam nearest the fire-box given away first, or it would have been carried toward the engine by number one, if that seam had not parted until after the girth seam next forward and on the other side of number three.

Experts may differ in regard to the point of first rupture along this sheet.

I have examined this piece carefully and find an old crack or "channel" cut along the edge of the horizontal tap referred to as now being at the ends of the sheet as it lies, and in some places so nearly through that it is difficult to detect the mere scale of good iron left, while in other places there remains a sixteenth ($\frac{1}{16}$) of an inch of sound metal. Fig. 2 exhibits a section of the crack.

(Fig. 2.)



Were this the weakest place in the boiler, and the *least thickness* here (one sixteenth ($\frac{1}{16}$) of an inch,) the tensile strength being equal to the average determined by the tests to be described, the pressure required to rupture such a boiler, ten feet in diameter, would be $44079 \times \frac{1}{16} \times 2 \div 120 = 47$ lbs. per square inch nearly.

A pressure of twenty-seven (27) or twenty-eight (28) pounds would burst it open where the least thickness was slightly more than one thirty-second ($\frac{1}{32}$) of an inch. It should be remembered that one portion may be supported, to some extent, by a neighboring stronger part.

Along this longitudinal seam the limit of strength would seem to be about thirty (30) pounds per square inch.

The original strength of the boiler was equal to about one hundred and twenty (120) pounds along the horizontal seams, its then weakest parts, provided that the iron had, when new, the average of the specimens which we have tested.

As the boiler was, at the time of its explosion, much stronger at the seams than in the channeled parts, no allowance has been made in the first calculations for loss in riveting.

In the vertical seams may be seen, in some places, similarly weakened portions, the cracks running usually from rivet to rivet, and here and there exhibiting marks that show the wedging action of the "drift-pin," and many places, both in longitudinal and girth seams, are cut by the chisel and marked by the "caulking tool."

The heating surfaces appear uninjured and in good order, and have, here and there, an incrustation of lime that may be due to the occasional use of sea water.

The smoke-stack has been thrown forward into the boat by the recoil aft of the boiler, and the safety-valves were somewhat injured by the blows received.

The steam gauge in the engine room escaped injury.

Examining the iron of the injured portions of the boiler, its appearance was found generally to be that of a fair quality of what is known as "charcoal No. 1," which brand stands next but one, in quality, to the exceptionally good iron known as "best flange iron."

In some places the sheets are made up of laminæ imperfectly welded together, owing to the incomplete exclusion of impurities while in process of manufacture.

This is an imperfection of frequent occurrence, but it rarely seriously reduces the tensile strength of the metal. Its quality will be better understood after examining the results of the formal tests.

The iron retains almost its full thickness except in certain lines such as I have described, or in spots of limited area where patches have been applied in several instances.

After examining the boiler I associated myself, as directed, with Messrs. Andrew Fletcher, Chas. W. Copeland and W. W. Vanderbilt, the Board of Experts appointed for the purpose by Supervising Inspector Addison Low, and proceeded with them in the examination of the steam gauge and safety-valves of the "Westfield," and in testing iron from the boiler.

On examination of the steam gauge, I found it to be No. 25,191 of the Am. Steam Gauge Co's make, with a scale ranging up to sixty (60) pounds per square inch. We tested this gauge by comparison with a carefully measured mercury column, up to thirty-five (35) pounds pressure, and it was found practically correct, the difference in reading at twenty-five (25) to twenty-seven (27) being less than a half pound, and the maximum degree of variation being, at very low pressures, one and seven tenths (1·7) pounds. This is an unusual degree of accuracy.

The safety valve, as found on the boiler, had been so badly injured by the explosion as to require the straightening of the lever and of the valve stem before it could be tested. This having been done, the weight was placed at a point upon the lever, twenty and one-half (20½) inches from the valve stem, where a chisel mark could be seen on each side of it. It then blew off at twenty-four (24) to twenty-four and a half (24½) pounds of steam. The weight was then placed six (6) inches further towards the end of the lever, at which point the Board found it before the removal of the valve from the boat, and in this position it allowed steam to blow off at twenty-eight (28) pounds. A third trial was then made with the weight as far out on the lever as it would go; steam then blew off at thirty-one (31) to thirty-three (33) pounds pressure, this being the maximum at which it can retain steam entirely. This valve has a diameter of five and a half (5½) inches, and an area of twenty-three and three-quarters (23¾) square inches.

The valve must lift nearly one and a half (1½) inches to obtain its full opening, but, on trial, when *set* at twenty-seven (27) pounds, it lifted only a quarter (¼) of an inch when the steam in the boiler exerted a pressure of forty-five (45) pounds.

The "government" or "lock-up" safety valve was next tried. This is called the "American valve." It is three (3) inches in diameter and has an area of seven (7) square inches. Were the main safety valve to stick in its seat, as frequently happens, this valve would be of little use, with steam rising rapidly. No engineer would consider so small a valve, on a boiler of this size, to be, in a proper sense, a "*safety* valve."

This valve, with the weight set at twenty-seven (27) pounds by the scale on the lever, blew off at thirty-two (32) by the test gauge. It

may possibly have been sufficiently injured by the explosion to cause this discrepancy.*

The remaining test, by the Board, was that of the iron of the boiler. Twelve pieces were cut from the course thrown from the middle of the boiler, and were numbered Nos. 1 to 6, inclusive, were cut crosswise the sheet, and 7 to 12, inclusive, lengthwise. Each of these pieces was reduced, at the smallest part, to an area of cross section as nearly equal to one-sixth ($\frac{1}{6}$) of an inch as was possible, and the exact section was then measured accurately, the greater dimension by a Darling, Browne and Sharpe Vernier Scale, reading to thousandths of an inch, and the smaller by a Browe and Sharpe "Micrometer Thickness Gauge," of equal delicacy.

Each piece was then broken with the following result:

No.	Original Breadth.	Original Thickn's.	Breaking Weight.	Ditto per Square Inch.	Fractured Breadth.	Fractured Thickn's.	Break'ng weight per inch. Fractured area.
1	0·544	0·299	6260	38475	0·545	0·295	38939
2	·552	·295	7000	43000	·536	·288	45336
3	·534	·294	surged,	no test.	·542	·285	
				minimum			
4	·555	·295	6200	37874	·544	·288	39556
5	·554	·293	6400	39433	·546	·289	40558
				maximum			
6	·553	·296	7260	45890	·545	·280	47575
7	·548	·296	7264	44784	·530	·283	48428
8	·553	·292	7000	43344	·525	·271	49193
9	·553	·310	7440	43409	·525	·273	51919
10	·554	·286	7450	47879	·526	·270	52514
				minimum			
11	·544	·299	6754	41512	·520	·274	47397
				maximum			
12	·544	.285	7680	49548	·522	·270	54507

Average across "grain" 40934 lbs. per inch of original area, 42718 on fractured area.
" with " 45079 " " " 50623 " "
" extension before breaking, 0·025 across the grain, 0·124 along the grain.

The broken pieces were then bent cold on an anvil to further test their quality.

I also sent a piece of the same iron to Professor Albert R. Leeds, Chemist of the Stevens' Institute of Technology, with a request that he would determine its specific gravity, which should be about seven and seven-tenths (7·7), a higher figure indicating a fine quality, and

* At the inquest, the engineer (Conolly), who set it under the direction of the U. S. Inspector a short time before the explosion, stated that it was set at 20 or 21 *by the scale*, blowing off at 26½.

a lower, the reverse, provided that the inward range is restricted within certain limits.

Prof. Leeds reports as follows:

STEVENS' INSTITUTE OF TECHNOLOGY,
Hoboken, N. J., August 11th, 1871.

Sir:—I have made two determinations of the specific gravity of iron taken from the exploded boiler of the "Westfield," and have obtained the same result, viz., 7·6 at 79° Fahr.

Very respectfully,
(Signed) ALBERT R. LEEDS.
Prof. R. H. Thurston. *Professor of Chemistry.*

Selected "Pennsylvania flange iron," sent to the Washington Navy Yard for trial, broke at from fifty-six thousand (56,000) to sixty thousand (60,000) pounds per square inch tensile strain, but such quality is seldom put into the shell of a boiler, it being usually reserved for parts more difficult to work or more liable to injury, as the furnaces, flue sheets and parts greatly exposed, either to action of flame or of external moisture.

Prof. Rankine, a leading English authority in engineering matters, gives "boiler plate, strong, 50,000."

Chief Engineer, Wm. H. Shock, U. S. Navy, who has had an unusually large experience with American irons, reports* that samples cut from rolled bars, furnished under contract, gave an average of fifty-nine thousand, one hundred and ninety (59,190) lbs. per square inch lengthwise, and fifty-three thousand one hundred and sixty-three (53,163) across the bar. Bar iron is usually stronger than plate.

Chas. Haswell; another eminent American authority, gives the strength of boiler plate† as fifty-three thousand eight hundred (53,800) lbs. lengthwise, and forty-eight thousand eight hundred (48,800) lbs. per square inch across the grain.

The irregularity of the iron from the "Westfield" indicates either a weakening effect from the wrenching and twisting produced by the explosion, or from its laminated structure; its low tensile strength, even at its maximum, and its low specific gravity, lead to the same conclusion, while its behavior and appearance, when subjected to the test of breaking cold, indicate that the metal itself was of good quality, although made into sheets of but medium value, and its extension under the breaking strain also confirms this conclusion.

* Journ. Franklin Institute, 3d series, vol. 59, p. 221.
† Ibid, 3d series, vol. 40, p. 338.

Having stated the facts ascertained, and the conclusions arrived at during my investigation in company with the Board of Experts, I will next consider, so far as it is proper, the causes that may lead to the explosion of steam boilers. These causes are now well understood by professional engineers. The thorough examinations and investigations resulting from thorough and systematic inspection of boilers both in our own country and abroad, have shown as conclusively as any scientific fact can be proven, that the explosion of a steam boiler may be invariably ascribed to some very simple and perfectly natural cause.

* * * * * * * * *

In fact, the causes of explosion are now so well understood as to be a matter of business calculation, and the "Boiler Insurance Companies" here and abroad take risks upon them, with far more power of controlling their losses by frequent and careful inspection, than have fire insurance companies.

Systems of inspection, both public and private, have done much, and may be expected to do more to reduce the frequency of these "accidents," even if they do not finally prevent them altogether.*

* * * * * * * * *

In this connection it becomes my duty to state how repairs may be necessitated by the action of oxidation or corrosion in its various forms.

Corrosion may affect a single spot in a boiler, in which case a "patch," if properly applied, should make the boiler nearly as strong as when whole.

A series of weak spots near each other may so weaken a boiler as to produce explosion, as may any considerable area of thin plate, although, when occurring in the stayed surfaces of a fire-box, the metal may become astonishingly thin. A sketch of spots of corrosion is shown in Fig. 3, which represents the cause of an actual explosion.

This cause of explosion may be either internal or external, and is induced internally by bad feed water, and externally by dampness or by water leaking from the boiler, either unseen or neglected. It is always dangerous to have any portion of a boiler concealed from frequent observation.

* Here follows a statement of the various causes of explosions and an *exposé* of some prevalent absurd theories on the subject, which were useful to a jury of non-professionals, but not to our readers.

Another form of corrosion is variously termed "grooving," "furrowing," and "channelling," and this is also a frequent cause of explosion. In this case the boiler is scored deeply, as by a tool of some kind, along the border of a seam, or where there occurs a sudden change of thickness of metal. These channels are sometimes

Fig. 3.

continuous, and sometimes interrupted by portions of good iron. They are probably caused by changes in form of the boiler with variations of temperature and pressure, some line of local weakness determining the line along which the plate shall bend, and this bending taking place continually, though ever so slightly, along the same line precisely, finally produces rupture.

Sometimes this action produces a narrow crack, and at other times, as the rust formed is thrown or scoured off the iron at the bend, leaving a comparatively clean surface, oxidation is probably accelerated, and the fault takes the form of a groove or furrow. If unperceived, this goes on until a rupture or an explosion occurs. Fig. 4 exhibits such a case, and represents the cause of an actual explosion.

This *change of form* in the boiler may proceed from either of the following causes, which act continually throughout the life of a boiler:

Changes of temperature occur as steam is raised or blown off from a boiler, and, when carrying twenty-seven (27) pounds of steam, its temperature becomes two hundred and seventy-three degrees (273°) Fahr., from which temperature it falls to that of the atmosphere each time that steam is blown off. It will change its form more or less, and will usually be subjected to some strain by this process.

Again, while actually at work, the steam space and upper portion of the water space are at the temperature of steam at the working pressure, while the lower part is continually varying in temperature from that of the feed-water to the maximum which it attains after entrance. This difference of temperature between the upper and lower parts of the boiler, as well as between other portions, causes a continual tendency to distortion, and, if this distortion be resisted, a stress is thrown upon the parts equal to that which would be required, acting externally, to remove the distortion, if produced. The stress is also equal to the mechanical force that would be necessary to produce similar distortion.

Thus, had the temperature of the main and upper part of the "Westfield's" boiler been, after the entrance of the feed-water, two hundred and seventy-three degrees (273°), or that due to about twenty-seven (27) or twenty-eight (28) pounds steam, while the feed-water had a temperature of seventy-three degrees (73°),—which happens to be the temperature of the hydrant water at the Stevens Institute of Technology as I write,—the bottom of the boiler having a temperature, in consequence, two hundred degrees (200°) below that of the top, the difference in length would be about one eight hundredth ($\frac{1}{800}$) and, if confined by rigid abutments, iron so situated would be subject to a stress of twelve and a half ($12\frac{1}{2}$) tons per square inch. But, in this case, one part would yield by compression and the other by extension, and if they were to yield equally it would reduce the stress to six and a quarter ($6\frac{1}{4}$) tons. Actually, in this case, the lower fourth and upper three-fourths would be more likely to act against each other, and the stress, *if the boiler had no elasticity of form*, would be about nine (9) tons. Any elasticity of form—and boilers generally possess considerable—would still further reduce the strain, and it very frequently makes it insignificant.

Again, I have assumed the worst possible case, the line of separation between the hot and cold parts being perfectly defined, instead of, as is actually the case, there being a gradual change of temperature from the bottom to a point some distance above, where the maximum temperature is usually attained, and the effect is thus very greatly and very favorably modified in most instances.

It is, however, evident that, acting on worn and weakened boilers, and on those that are deficient in elasticity of either material or form, or when acting to strain a seam already injured by the use of the "drift pin," or by careless workmanship in other respects, or again

where unanticipated and unprovided for forces act with it, serious results may be produced, and in fact, such results have actually occurred in isolated cases, with even new boilers.

The action just described affects only the vertical or "girth" seams of the "Westfield's" boiler. An assisting stress also arose in this case, from insufficient support apparently.

Another, and with boilers of large diameter like this, an important cause of variation of form and consequently of "channelling," is found in variations of internal pressure. This would affect principally the horizontal seams.

When the cylindrical shell, ten feet in diameter, was empty, it had a tendency which must, to some extent, have produced an effect to flatten down, taking an elliptical cross section, which action would be of greater extent as the boiler was filled with its great weight of water when steam was raised, its pressure assisted the elasticity of the iron in the effort to restore the cylindrical form, and thus, with all changes of weight and pressure, the boiler would be changing its form in such a manner as to affect the horizontal seams, as the changes of temperature already described affect the other seams, and produce channelling. Here a horizontal seam actually gave way. In either direction, this form of corrosion might be initiated by the previous existence of lines of weakness. Such lines exist in the "Westfield's" boiler, produced by careless or unskilful use of the chisel and the caulking tool. Part of the boiler have been removed and will be placed before you, and you will be able to exhibit to the jury the ends of the middle course of plates which blew off against the side and bottom of the boat, and also a part of another adjacent and similarly situated seam which shows, also, a similar channel or crack. The latter also illustrates that maladjustment of rivet holes, which was formerly, even by good engineers, considered to justify the use of the drift pin.

The steam gauge, the safety valves, and the pieces of iron cut from the boiler and tested, will also be brought in. The latter are all carefully marked with the weight at which they broke, and with a line indicating the direction of the "grain of the iron."

I omit all reference to the inspection of boilers as a means of preventing explosions, as I do not think it is required by my instructions, and because I expect that it will be very fully considered on the inquest by the Experts whom you have summoned, the possibility of any inspection detecting the weakness of the "Westfield's" boiler, being one of the principal subjects of your investigation.

I trust that the facts that I have presented will be found useful by assisting you so to direct your inquiries as to determine fully the cause of a disaster by which a hundred lives were destroyed, and I also hope that your examination may have a further result in aiding the members of my profession in the effort to secure immunity from such calamities in future.

I have endeavored to present essential facts only, and to make my statements clearly, simply and without prejudice.

Very respectfully,

(Signed) R. H. THURSTON,
Professor Mechan. Engineering.

Coroner P. H. Keenan,
11 City Hall, New York.

The weight of evidence both before the Coroner and before the official Board of Inquiry—convened to determine how far the Inspector, who had passed the boiler on the 12th of June previous, was responsible for the explosion—indicated that the explosion occurred in consequence of the existence of lines of channelling and long existing cracks, by which the boiler was so weakened that, on the 30th of July, the pressure of steam being allowed by the engineer to rise somewhat above the pressure allowed by the Inspector, the boiler was ruptured, giving away along a horizontal seam and tearing a course out of the boiler; the thus separated parts of the shell were thrown apart as described in Prof. Thurston's report.

The testimony indicated very decidedly, the inefficiency of the "hydrostatic test" and the value of the "*hammer test*" *in experienced hands*, in detecting all classes of defects. In this case, it seems very nearly certain that the boiler had been strained at the channelled parts by the water pressure, without awakening even a suspicion in the mind of the Inspector of their existence, doing actual injury and having not the slightest compensating good result.

It was also shown that the U. S. Inspectors had been in the habit of doing their work very carelessly in many cases. It is, however, expected that, under this unexpected stimulus and under the vigilant eye of Inspector General Belknap, who has entered upon his duties since this sad event, a thorough reform and an effective system will be inaugurated.

The verdict of the Coroner's jury inculpates the officials of the ferry company, and prompt action has been taken against them by the proper authorities of both New York and Brooklyn.

A Coroner's jury has since brought in a verdict inculpating the Inspector who passed the worn-out boiler of the tug "Starbuck," which exploded in New York harbor.

Such prompt and earnest action will undoubtedly have a good effect in impressing the officers of steamers and the U. S. Inspectors with the magnitude of the responsibility resting upon them, but we cannot hope for immunity from such calamities until the law is so amended as to compel the U. S. Inspectors, and all Inspectors in fact, to make, at least, quarterly inspections, and to use a light hammer in searching for defects in every sheet and along every seam, and to make provision, also, for keeping constantly in training a large body of Assistant Inspectors, of sufficient experience to be able to detect infallibly every such case as the *Westfield*.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 176.)

In a former article the difference between English and American machine construction, with some of the reasons that govern it, was briefly alluded to. This branch of the subject should, no doubt, have occupied a greater share of the matter that has appeared, for without an understanding of the very different conditions of the market in which the machines are sold, and the purposes to which they are applied, we can expect no fair criticism of the designs that have appeared of English wood-cutting machines.

We will further say, that in the course of these articles the subject of wood-cutting machines has to be considered in reference to general use, and without assuming any local standard to determine their merits. The correctness of this will not be questioned when we consider how various are the requirements in different countries, which brings us to difference between English and American machines as shown in the engravings which have appeared in the *Journal*.

In the United States the manufacture of wood-machines is almost exclusively for our own use, and nearly all can be fairly considered as special machines. While there is some analogy between the wants of most other countries in this kind of work, America is an exception, the conditions being totally different. Here money is scarce, labor is dear and skill is plenty. Contrast this with the countries where English machines find a market, and we find almost an opposite set of con-

ditions—money commanding a low rate of interest, labor cheap and a want of skill. This, with the difference between the timber of America and that of other countries, accounts for all and even a greater difference than we find between the machines as illustrated in these articles.

In speaking of this general difference in the character of the machines there is no desire to evade the charge of bad designs and want of workmanship that has been so often applied to American wood-machines; they certainly deserve it, as a rule, the fact being that they do not, in any degree, represent American engineering skill, which in other branches has attained a reputation that is fast creating a market for our products in the old world.

Plate VIII, Fig. 1, represents a lumber-mill, from the designs of Messrs. A. Ransome & Co., the manufacturers, being a true side elevation on a scale of $\frac{1}{24}$th.

The general construction conforms to that of the American "Circular Saw-mill," with a "top saw." It is, however, more strongly framed, and the design is a good one. The simultaneous setting device contains a hint for mill men in the tangent wheels for moving the "dogs;" the tensional strain upon the setting shaft will, under this arrangement, be so inconsiderable that the two "heads" will "set true" at any distance apart.

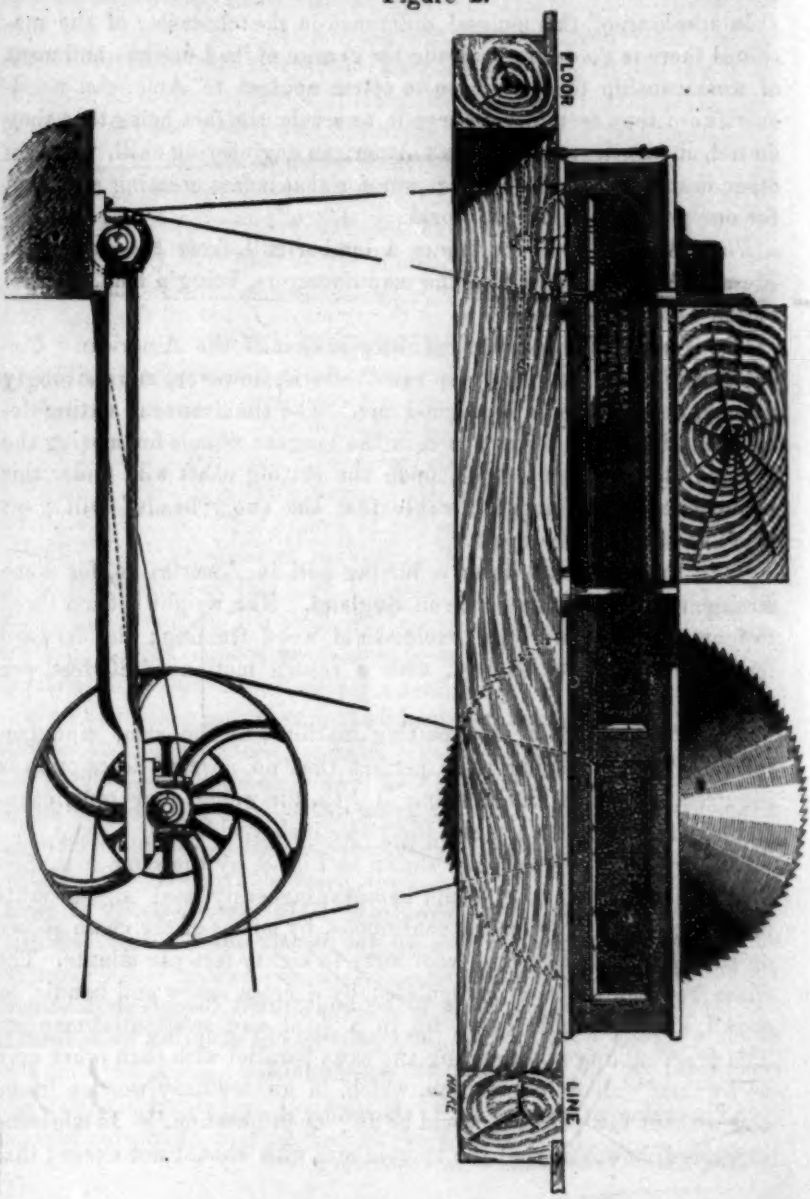
This, that we would term a lumber-mill in America, is, for some strange reason, called a bench in England. The weight is from three to four and one-half tons, exclusive of wood framing; the forward feed is from 10 to 40 feet, with a return motion of 80 feet, per minute.

Fig. 2 represents a cross-cutting machine, by the same manufacturers. The engraving is so perfect that no special description is required. Scale of the drawing is $\frac{1}{24}$th, the weight four tons, capacity eighteen inches deep and forty-two inches wide.

The double "edging" saw shown at Fig. 3, by the same manufacturers, is a machine that could be advantageously used in our mills in this country. The feed is continuous, by means of the chain shown on the right, with a feed of from forty to eighty feet per minute. The space between the saws is regulated by a cross screw and handle, as shown, and the whole fitted up in a good and substantial manner. The practicability of operating two saws parallel with each other may be by some called in question, which, in an ordinary wooden frame and without saw-packing, would be an "open question." It might be suggested, however, that the trouble met with should not exceed that

which is experienced with one of the long saw-gauges that we see in common use, that extends past the plate, and even the whole length of the bench in some cases.

Figure 2.



NOTES ON SPRINGS.

By J. H. Cooper.

Elasticity of Spiral Springs.—"In order that spiral or helical springs may be accurate for measuring forces, the figure of the spring should be a true helix.

"It is more favorable to accuracy to measure a force by the extension than by the compression of a spiral spring.

"The pair of equal and opposite forces by which a spiral spring is stretched, should act exactly along the axis of the helix. The best form of section for the wire of which the spring is made is circular, because the extension of the spring depends on the torsion of the wire; and the laws of torsion are known with greater precision for a circular form of section than for any other.

"The following formulæ show the relations between the load and the extension or compression of the spring:—

"Let r be the radius of the cylinder containing the helical center line of the spiral spring, as measured from the axis to the center of the wire; n, the number of coils of which the spring consists; d, the diameter of the wire; C, the co-efficient of rigidity or transverse elasticity of the material; f, the greatest safe shearing stress upon it; W, any load not exceeding the greatest safe load; v, the corresponding extension or compression; W_1 the greatest safe *steady* load; v_1 the greatest safe extension or compression; then

$$\frac{W}{v} = \frac{C d^4}{64 n r^3}; \quad W_1 = \frac{0.196 f d^3}{r}; \quad v_1 \frac{12.566 n f r^2}{C d}.$$

"The greatest safe *sudden* load is $\frac{W_1}{2}$.

"If the wire of which the spring is made is square, and of the dimensions $d \times d$, the load for a given deflection is greater than for a round wire of the diameter d, in the ratio of 281 to 196, or of 10 to 7, nearly.

The values of the co-efficient, C, of transverse elasticity of steel and charcoal iron wire, in lbs., on the square inch, range between 10,500,000 and 12,000,000.

"By the greatest stress is to be understood the greatest stress which is certain not to impair the elasticity of the spring by frequent repetition: say 30,000 lbs. on the square inch.

"The value of the ratio $\frac{W}{v}$ borne by the load to the extension,

ought to be ascertained by direct experiment for every spring that is used in dynamometers or indicators."—*Rankine's Millwork*, p. 389.

"The best form of longitudinal section for each spring is that which gives the greatest flexibility for a given strength, and consists of two parabolas, having their vertices at two ends of the spring, and meeting base to base in the middle: that is to say, the thickness of the spring at any given point of its length should be proportional to the square root of the distance of that point from the nearest end of the spring. To express this by a formula, let

c be the half length of the spring;

h the thickness in the middle;

x the distance of any point in the spring from the end nearest to it;

h' the thickness at that point; then

$$h' = h \cdot \sqrt{\frac{x}{c}}$$

"The breadth of each spring should be uniform, and, according to General Morin, should not exceed from 1½ to 2 inches. Let it be denoted by b.

"The following is the formula for calculating beforehand the *probable* joint deflection of a given pair of springs under a given tractive force:—

"Let the dimensions, c, h, b, be stated in inches, and the force, P, in pounds.

"Let y denote the deflection in inches.

"Let E denote the *modulus of elasticity* of steel, in pounds on the square inch. Its value for different specimens of steel varies from 29,000,000 to 42,000,000, the smaller values being the most common. Then

$$y = \frac{8 P c^3}{E b h^3}$$

"The deflectiou should not be permitted to exceed about one-tenth part of the length of the springs."—*Rankine's Millwork*, p. 386.

Rules for proportioning spring plates.—"The theory of the resistance of materials to flexure, according with the known results of experiment, shows that when a metallic plate of a constant rectangular section is fastened at one end, and subjected at the other to the action of an effort P, perpendicular to its length or primitive direction; or when an elastic plate of the same form is placed freely upon two

supports, and subjected in the middle to an effort P, directed in the manner described, its flexure, F, so long as it does not exceed the limits of elasticity, will be:

"1st. Proportional to the effort P;

"2d. Proportional to the cube of the arm of the lever c of this effort;

"3d. In an inverse ratio of the width a of the plate, in a direction perpendicular to the plane of flexure;

"4th. In an inverse ratio of the cube of the depth b of the plate, at the fixed point for the first case, and at its middle for the second;

"5th. In an inverse ratio of a number E constant for each body, called the co-efficient or *modulus of elasticity*, and which expresses in pounds the weight required to extend a prismatic bar of the same material, with a unit of surface, for its transverse section, to double its primitive length, if such change in its dimensions may be made, without varying the value of E.

"Furthermore, if the longitudinal profile of the plate presents the parabolic form of solids of equal resistance, the flexure will be double that of a plate of uniform thickness throughout its length, subjected to the same efforts; while the resistance to rupture is the same in both.

"Hence, we have for springs for equal resistance, conformably to theory and experience, the relation

$$f = \frac{\text{P. C}^3}{\text{E. } a. \ b.^3},$$

A formula, by means of which we can calculate any one of the quantities composing it when the others are known. I have found in the construction of many spring plates, that if made of good German steel, properly tempered and annealed, the value of the co-efficient of elasticity to be used will be

$$\text{E} = 4273700000 \text{ pounds per square foot.}"$$

Ratio to be established between the different proportions.—"The width a of the plate should, at most, not exceed the limit of from ·1312 feet to ·164 feet, since the warping produced by tempering increases with its width, and creates difficulties in its adjustment.

"An examination of the springs which I have made, shows that the flexures of springs remain proportional to their efforts, when for the strongest they do not exceed $\frac{1}{10}$ of their length, and for the weakest $\frac{1}{9}$, the measure being taken from the place where they are embedded.

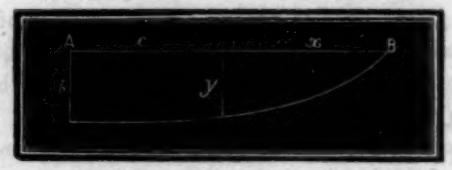
"With these data it will be easy to calculate the thickness b to be given to the plate at the place of its setting, so that under a determinate effort it may take a known flexure. It is derived from the following formula:

$$b^3 = \frac{P c^3}{E a f}.$$

Longitudinal profile of the plates.—"The above dimensions being obtained, we determine the form of the longitudinal profile by means of the formula:

$$y^3 = \frac{b^2}{c} x$$

In which b and c being the quantities already designated,



x will represent the abscissa of the curve measured from its origin B, and y will be the corresponding ordinate."—*Morin's Mechanics.*—*Bennett*, 1860, p. 34.

In order to test the effect of compression on springs of the conical volute form, made of steel strips of rectangular section bent flatwise, and afterwards tempered in oil, I had a spring made of a piece of steel 1 inch wide, 6 feet long, and No. 14 wire gage thick. This was first formed into a flat volute, having an outside diameter of $4\frac{3}{8}$ inches and an inside aperture of $2\frac{7}{8}$ inches, the band of steel making 7 turns. The spring thus made was drawn out $2\frac{5}{8}$ inches, thus making a conical volute whose entire height was $3\frac{5}{8}$ inches.

The compression due to certain weights will be found in the following:

Height of spring in inches.	Wts. in lbs. applied.
$3\frac{5}{8}$	0
$3\frac{1}{4}$	5
$2\frac{7}{8}$	10
$2\frac{3}{8}$	15
$2\frac{1}{8}$	20
$1\frac{1}{2}$	25
1	30

Another made of steel 1 inch wide, No. 14 and $6\frac{1}{4}$ turns, tempered in oil, and same diameter, gave the following:

5½	inches	high.	,0 lbs.
4½	"	"	10 "
3½	"	"	20 "
2½	"	"	30 "
1½	"	"	40 "

Rule for the strength of Locomotive springs:

$$L = \frac{B\,T^2\,N}{11{\cdot}3\,S} \qquad N = \frac{11.3\,S\,L}{B\,T^2}$$

In which S = span of spring, in inches.
B = breadth of plates, in inches.
T = thickness of plates, in sixteenths of an inch.
N = number of plates.
L = safe load on spring, in tons.

Molesworth Pocket Book, 1865.

Springs.—The flexure of a spring is proportional to its load and to the cube of its length.

Deflection of a carriage spring.—A railway carriage spring, consisting of 10 plates $\frac{5}{16}$ in. thick, and 2 of $\frac{3}{8}$ in. thick; length 2 feet 8 in.; width, 3 in., and *camber* or spring 6 in., deflected as follows, without any permanent set: ½ in. under a half ton; 1 in. under one ton; 1½ under one and a half tons; 2 in. under two tons; 3 in. under three tons, and 4 in. under four tons.—*Haswell*, 1867.

(To be continued.)

THE OVERFLOW OF THE MISSISSIPPI RIVER.

By D. S. Howard, C. E.

The recent New Orleans flood is another reminder of the neglected laws that govern the action of water over beds and between banks of yielding material. Like all other calamities, it is calculated to draw our attention to precautionary measures against the recurrence of other similar disasters.

It would seem to be too plain to require repetition, that the temporary effect of the Levee system, for promoting the overflow of the Mississippi banks, is worse than useless. The rise of the bed of the river is as sure to follow every freshet, which is confined within its banks, as it is that the freshets bring down sediment that is not disposed of by crevasses, rendering the section of the stream less than the capacity required by the next freshet, consequently requiring increased height and strength of levee every year.

It may not be clear to every person, how the sediment should be deposited more by freshets than by a less flow of water, on the same bed. But there is more sediment in a freshet than in low water, which is deposited more readily in proportion to the difference between the inclination of the surface of the water in a freshet, and in low water, with regard to the inclination of the river bed, which is the same in both cases. The rise in the water being greater above than at the mouth, to give the necessary velocity to dispose of the surplus water of a freshet, confined within limited banks, increases the inclination of the surface, while the bed remains the same; it also increases the section of the stream more above than below. This, together with the action of gravity on the water with increased motion and inclination of surface, and consequent greater reaction on the bed, has the effect to diminish the motion of water nearer the bed of the stream, and throw down more sediment than will be deposited when the bed of the stream is nearer parallel with the surface.

Whatever difference of opinion may exist about the theory, the fact has been established by experiment that the motion of water near the bed of streams is less in freshets than in low water. Common observation also teaches us that the beds of the lower waters of all similar streams to the Mississippi, where the freshets are confined within the limits of their low water banks, are annually rising. With these facts in full view, it seems easy to comprehend the necessity of adopting some other means of avoiding all similar catastrophes by looking towards the source of the evil instead of confining our gaze on the evil itself. By such a deviation from the too common course, we shall soon see that freshets may be arrested near where they originate, much easier than they can be confined, after a combination of a large number of tributaries have collected their forces and concentrated them on a main outlet like the lower Mississippi.

By the selection of proper sites for reservoirs at or near the head waters of rivers, it is very easy to see that much less expense of dams will prevent a freshet than will prevent an overflow of the lower river banks by levees.

The argument against reservoirs is the danger of breaking away, of which there is no necessity whatever, if properly planned and constructed. If the reservoirs be numerous, as they must needs be on the Mississippi, it would not be at all probable, in any event, that all would break at the same time, or enough to do any harm; whereas, the dykes, being necessarily more extensive, are proportionably more

liable to break in some part of the two long lines, always doing more or less damage, according to the extent of the freshet and the location of the breach, without the possibility, sometimes, of repairing the crevasse until the freshet subsides; while a reservoir dam may be immediately repaired, ready to check the torrent in case of any other similar accident.

Many of the reservoirs may be located as to be worth more than their cost for the water power they would provide, but the greatest advantage to be derived from them on the Mississippi River would be the benefit to navigation, by affording more water in a low time, and preventing the accumulation at the mouth, which is now the effect of every freshet.

It is now well known that the bar at the mouth of the Mississippi is the worst at the time of the highest freshets, affording the least depth of water for the entrance of ships. But the low season allows the salt water to flood the bar, and float up the new deposit made on the clean washed low water bed, in the shape of what is called "mud lumps," from the greater weight of the salt water to that of the newly deposited sediment, assisted, perhaps, by fermentation of vegetable matter contained in the sediment, during the hot season, subsequent to the freshet; after which there is a greater depth of water over the bar, until another freshet has forced the heavy salt water from the location, when another bar is formed as before.

This consideration alone should be sufficient to induce any Government, with competent foresight, to institute an inquiry, at least, calculated to solve the mystery of the right plan for overcoming the great evil attending the uncontrolled freshets of the Mississippi River, which would also provide a specific for the freshets on all similar streams as well.

No investment of public lands or public money could be made that would afford the same returns as the permanent improvement of the Mississippi and its tributaries by the Reservoir system. This plan has the uncommon merit of being progressive.

When a reservoir is properly constructed, it is a permanent improvement as far as it goes, whether the system be extended or a return to any other system be adopted, it works equally well; therefore, if the estimates of the engineer in charge be not satisfactory, an experiment may be made without a total loss, as with most experiments. The amount of water withheld from a freshet by a reservoir reduces the freshet and its effects, and the additional levees required,

in exact proportion to the capacity of the reservoir, for all time to come, whether any more be constructed or not; and if the Reservoir system be carried out to its fullest extent on any river like the Mississippi, so as to equalize the flow of water at all times, the stream will soon acquire a fixed regimen; every yielding obstruction to the full capacity of the stream will soon have given way to the continued action of the water, affording an uninterrupted navigation, with a permanent location of the stream, which can be obtained by no other means.

The following are some considerations in favor of the Reservoir system in contrast with the Levee system:

Reservoirs require no additions or repairs from year to year, if properly constructed.

Levees require additions every year, in proportion to the amount of deposit on the bed of the river left by the preceding freshet.

Reservoirs retain the sediment of the freshet in proportion to the amount of water retained, and lessen the accumulation in proportion to the diminished height and velocity of the surface current.

Levees increase the amount of sediment in proportion to the increase of height and velocity of the surface current by the freshet.

Reservoirs create a fixed regimen and location for a stream, when the system is fully carried out, which frees the banks above the surface of the water from abrasion by currents, while the lower banks and bed of the stream are soon washed clean of their yielding particles, producing a uniform pure, clear water stream in all seasons of the year, affording the least amount of material for the bar at the mouth.

Levees, when the most successful, cause the highest freshets and the greatest amount of abrasion of the banks, consequently the most variation in the course of the stream, affording the largest amount of material for the bar at the mouth.

Reservoirs, by promoting the overflow of large surfaces of land in warm climates, lessen the amount of fresh material for miasm, so abundantly supplied by freshets, and so prejudicial to health.

Levees, if permanent, must necessarily expose a large amount of saturated surface, covered with sediment, between the levees, after every freshet, to the action of the sun; but, if not permanent, the disaster to health as well as property is very great.

Richmond, Virginia, 1st July, 1871.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 173.)

In Table II are given the observed and computed co-efficients of another Telegraphic Meter, much heavier than the last, of the form shown in Figure 4; and of a Woltman's Meter which was tested with the Telegraphic Meter:

Table II.

Velocity in feet per sec.	Telegraphic Meter Co-efficients.			Woltman Meter Co-efficients.		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
1·0					0·493	
1·4		1·322				
1·5	1·171	0·170	+0·001	0·420	0·412	+0·008
2·0	0·961	0·971	—0·010	0·388	0·387	+0·001
2·5	0·868	0·882	—0·014	0·375	0·374	+0·001
3·0	0·852	0·837	+0·015	0·369	0·369	000
3·5	0·840	0·825	+0·015	0·369	0·369	000
4·0	0·833	0·822	+0·011	0·368	0·368	000
4·5	0·819	0·819	000	0·366	0·366	—0·001
5·0	0·813	0·816	—0.003	0·360	0.366	—0·006
5·5	0·808	0·813	—0·005			
Sums			+0·010			+0·003
Mean			+0.0011			+0·0004

These co-efficients were obtained in the same manner as the former, but they decrease much more rapidly at first, so that the same curve cannot be used. It was found that they would best agree with an ellipse having the same minor axis as the other, 3·44; but a major axis only one-half as great, 4·10. The computed co-efficients were obtained in the same manner as those in Table I. After leaving the curve, the observed co-efficients follow a line making a small angle with the tangent.

Unfortunately, there were no observations at high velocities made with the Telegraphic Meters; therefore we cannot exactly determine the law of change of the co-efficients in fast currents; but they probably vary little from the last ones given in the tables.

M. Baumgarten* gives a series of observations to determine the co-efficient of the Woltman meter constructed by him, and used in his velocity measurements in the Garonne. These observations were made both by drawing the meters through still water, and also by

* Annales des ponts et chausses, Tome XX. Paris, 1849. Page 327 *et seq.*

fixing them to an arm which could be revolved at different velocities around a vertical axis. The co-efficients are given in Table III:

TABLE III.

Velocity in feet per second.	Co-efficients.		
	Observed.	Computed.	Difference.
0·950		1·622	
1·121	1·495	1·492	+0·003
1·454	1·387	1·409	−0·022
2·116	1·329	1·329	000
2·571	1·313	1·305	+0·008
2·842	1·313	1·298	+0·015
3·579	1·309	1·295	+0·014
3·732	1·285	1·295	−0·010
3·958	1·293	1·294	−0·001
6·304	1·279		
11·518	1·260		
11·966	1·264		
Sums			+0·007
Mean			+0·0009

The computed co-efficients in this table are taken from the second curve; and, as the observations were too few to group them for every half foot per second, they are given at the recorded velocities. These co-efficients decrease more beyond the curve than those of the other meters.

The co-efficients for the tachometer, hydrometric tube, &c., can be obtained in a similar manner.

The Pitot's tube, constructed by M. Darcy,* was tested by all three of the methods mentioned.

Compared with surface floats, the co-efficient was	.	1·006
Drawn through still water, "	.	1·034
In water of known velocity, "	.	0·993

The second is much too large, and this discrepancy was accounted for by the fact that in these experiments the tube was placed in front of a boat which was drawn through a canal. The effect of the motion on the boat would be to raise the forward end, and thus incline the tube to the direction of motion. This would reduce the indications of the instrument a little, and thus increase the co-efficient. Other tubes, however, have had a much smaller co-efficient than this.

* Recherches Hydrauliques. Enterprises par M. H. Darcy, et continués par M. H. Bazin. Paris, 1865. Page 19.

M. Baumgarten says:* "Many persons have objected to the method of obtaining the co-efficient by drawing the meter through still water, ... and pretend that there would be a difference between this mode of observation and that of noting the number of revolutions of the meter when placed in a current of known velocity. I have undertaken a series of experiments for ascertaining whether these doubts have any foundation."

He made two series of comparisons of the meter with surface floats, in one of which the co-efficients were found to be a little larger than those obtained by drawing through still water, and in the other a little smaller; leading him to the conclusion that these two methods gave practically the same result.

The Telegraphic meters were also compared with surface floats. Table IV gives the results of the comparison of Meter No. 1 with floats in a small canal at Ogdensburg. The floats were run over a distance of 200 feet, at a depth of three feet, their time being taken by a chronometer, and the meter was placed at the same depth in the center of the distance run, as nearly as possible on the line of the passing floats.

TABLE IV.

No. of Observations.	Velocity of Current in feet per second.			Arithmetical sum of differences of single Observation.	Mean of Differences.	Range of Differences.
	By Floats.	By Meter.	Difference.			
24	1·992	1·980	+0·012	2·314	0·096	+0·219 to —0·162
6	1·876	1·916	+0·040	0·368	0·061	+0·064 to —0·161
6	1·476	1·434	—0·042	0·443	0·074	+0·157 to —0·092

Here the difference between the mean velocities is small, while the individual floats differ greatly from the meter velocities, the float only giving the speed of the current at the moment of passing, while the meter shows the mean velocity for the time the float was running over the whole distance.

Comparisons were also made between the Propeller meter and floats, at the depth of one foot below the surface, in St. Clair river.

The mean velocity given by the 50 floats was . . .	3·619
And that given by the meter was	3·655
Difference	—0·036

* Annales des Ponts et Chausses, page 353.

There was a light up-stream wind at the time of observation, which probably retarded the floats a little.

The method of observing the floats will be explained hereafter.

Navier gives a formula for the correction of the velocity obtained by floats, assuming that the velocity of the water is uniform at the depth to which the body is immersed:

$$x = \left(\frac{2\,g\,\mathrm{M}\,\mathrm{I}}{m\,\mathrm{S}}\right)^{\frac{1}{2}} \qquad \text{in which}$$

M = the displacement of the float,
S = the greatest immersed area,
g = the velocity due to gravity,
m = a constant, depending on the form of the float,
x = the correction required, which is always minus.

Mr. J. B. Francis found the constant m for floating rods to be 0·77 nearly.*

The double float also requires a correction, but its determination is much more difficult than the others.

In 1867 I was ordered by the Superintendent of the U. S. Survey of the North and Northwest Lakes, to make velocity measurements for the determination of the outflow of the lakes. The latest current measurements were those made by Humphreys and Abbot on the Mississippi,* and that being the largest river ever attempted to be gauged I adopted their methods of observation.

They used the double float which had been previously tried by Mr. Chas. Ellet, Jr., on the same river. Many kinds were tested, but the best was found to be an old paint-keg with the bottom knocked out, for the lower float, and for the upper a tin ellipsoid, about six by one and a half inches, bearing a small flag on a wire passing through its centre. These floats were connected by a cord from one to two tenths of an inch in diameter, and of different lengths, according to the depths at which the measurements were to be made. It was assumed that the upper float would have no affect on the lower, but would merely serve as a surface guide to show its position.

Their method of observation was as follows: "Two parallel cross sections having been sounded out 200 feet apart, a base line of the same length was laid off on the bank perpendicular to both. An observer with a theodolite was stationed at each end of the line.

* Report upon the Physics and Hydraulics of the Mississippi River, &c. Prepared by Capt. A. H. Humphreys and Lt. H. L. Abbot. 1861.

"Two skiffs were stationed in the river, one considerably above the upper and the other below the lower section line, the former being provided with several keg floats. At a signal from the engineer at the upper station, a float was placed in the river. The keg immediately sunk to the depth allowed by the cord, and the whole float moved down towards the upper line. The observer at the lower station followed its motion, keeping the cross hairs of his telescope constantly upon the flag. At the word 'mark,' uttered by his companion when the float crossed the upper line, he recorded the angle shown by his instrument, and then, setting his telescope upon the lower line, watched for the arrival of the float. In the meantime the observer at the upper station, whose theodolite supported a watch with a large seconds hand, recorded the time of transit of the float across the upper line, and followed the flag with his telescope. At the word 'mark,' given by his assistant when the flag crossed the lower line, he recorded the time and angular distance from the base line. The float was picked up by the lower boat."*

Where these observations were made the river was from 2000 to 4000 feet wide, while the base was only 200 feet. This base seems altogether too short, for the exact location of a *fixed* point is difficult when its distance is ten or more times the length of the base; but when this point is moving from two to eight feet per second, its location must be very uncertain.

It would also seem to be impossible to read and record the angles and time while a fast float was passing over so short a distance.

In the location of the soundings taken on these cross sections a base of from 400 to 1000 feet was used; and it seems strange that a shorter base was accepted for the location of the small, fast-moving float, while the boat could be held by its oars nearly stationary.

When this method was first tried on the outflow of the lakes, it was found that even in this short distance there was great difficulty in hearing the call over the wash of the waves and the ordinary noises of a large river, and also that the distance run by a fast float between the time one observer saw it passing the cross hairs of his telescope and the other heard his call was quite appreciable.

The base line was therefore increased to one-third the width of the rivers where measurements were made, and a wire from a battery run from one station to the other, having a telegraphic relay, or sounder and key, in the circuit, placed near each observer.

* Humphrey's and Abbot's Report, page 225.

Then, when a float put out from the anchored boat approached the upper section line, the observer commenced counting the beats of his chronometer, and called his assistant by a few rattles of his key. The latter turned his theodolite upon the flag, and followed it till a single touch of the key by his companion signalled its passing the upper line, when he clamped his theodolite and read the angle, the observer at the upper station recording the time of passing.

The float was signaled by the lower observer in the same manner when it passed his station.

This method apparently eliminated most of the errors of location mentioned above, but still the results were not satisfactory.

(To be continued.)

Glass Ornamentation Made Easy.—Mr. Tilghman, whose ingenious process of cutting hard substances has attracted so much attention, informs us that sand falling from a height of about thirty feet upon glass will depolish its surface, and will, in fact, cut through the flash of colored glass. This affords an easy mode of experimenting in the ornamentation of glass, partially protected by paint or other means. The specimen of engraving to which we called attention in September will shortly appear.

Horse Power of Steam Boilers.—We again call attention to that portion of the report of the Committe on the Horse Power of Steam Boilers in which they request that any engineers who have made a trial of the heating surface required to evaporate a cubic foot of water per hour, on any well known type of boiler, would send the particulars of the result to the Secretary of the Franklin Institute.

The particulars desired in connection therewith are as follows:

Description or sketch of boiler. Quantity of heating surface—fire-box and flue. The setting of the boiler. Area of grate surface. Height of chimney. Natural or artificial draught. Kind of coal. Number of pounds *consumed* per hour. Temperature of feed. Cubic feet of water evaporated per hour; and at what pressure of steam. Character of steam, wet or dry. Temperature of escaping gases. Duration of trial.

Mechanics, Physics and Chemistry.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

The stereoscope has long since ceased to be a popular novelty, and has gradually become recognized among the established aids to instruction and investigation, but its full value in either respect is scarcely yet generally fully appreciated, or by any means exhausted. Although found in almost every family there are few cases in which systematic or complete sets of stereographs upon any subject accompany it. The stereographs appear to have been purchased at haphazard, as they chanced to please a passing fancy, without any definite end in view, and in their comparative isolation from others bearing upon the same point they lose much of their value. A friend of the writer, who very early recognized the value of the stereoscope in this respect, set about making a complete collection of Parisian views, and, with Galignani's Guide in hand, made a thorough study of Paris, preparatory to a visit to that city. The leisure moments thus systematically enjoyed would have been a great source of profit even had he never carried out his original intention, but his report was that upon his arrival in Paris many prominent places in the city had a familiar appearance, that he felt quite at home, and was spared much annoyance and great waste of time, as any one who has been suddenly dumped down in a foreign city can well appreciate. The same plan was subsequently followed with reference to Rome, and other places, with equally satisfactory results. There are other fields just as open to stereoscopic study, in science, art, architecture, &c. Besides the stereographs of different places and objects, now invariably photographic, a great many of those accompanying the earliest stereoscopes, consisting of lines and dots, and colored figures, possess an interest peculiar to themselves. A systematic collection of these would illustrate the history of the development of the instrument, and of disputes concerning the theory of binocular vision, as well as of various questions in physics that have been referred to the stereoscope for solution. There is a charm in the simplicity of these stereoscopic drawings, free from all unnecessary accessories, and in the directness with which they illustrate principles, although at first sight they often appear objectless. It is proposed in these notes to give

some of the results of a series of experiments on binocular vision, some of which seem to contradict statements frequently made, because originally sent forth with the impress of high authority.

The query as to why, or how, having two eyes, each capable independently of receiving and reporting impressions of external objects, we do not get two impressions, or see double, when we employ both eyes, is a very natural one, and one that has received many explanations; but equal interest attaches to the investigation of the other nearly related question, as to the part the two eyes play, and the manner in which they operate together, to give different, and not only not confused, but clearer, and more definite perception of external objects than we can obtain with one eye. For it is an undisputed fact, that, within certain limits, say one hundred yards, they afford us an additional criterion of distance, and, through this, enable us also to perceive more readily and exactly the form or relief of objects. The usual criteria of distance independent of this, viz., the variation in apparent magnitude of known objects, number and distinctness of details in the object, number of intervening objects, vivacity of the tint, chiaro-oscuro, atmospheric perspective, geometric perspective, the effort in accommodating the eye to different distances near the limit of distinct vision, &c., enable us, by long experience, to make an estimate of distance, in most cases, with tolerable exactness, and are all equally available to one eye or both; but the estimate obtained by employment of both eyes is always most satisfactory.

The familiar statement that with but one eye open it is impossible, at arm's length, to pour wine out of a bottle into a wine glass, or to snuff a candle, &c., does not impress the mind of the person accepting it, with the utility of two eyes, as forcibly as an actual experiment. The attempt to bring the tips of two fingers together with the hands at arm's length will, perhaps, satisfy most persons, if not, a trial of the following experiment will always bring with it a pleasing surprise, even to those fully admitting and comprehending the above statements.

Let one person be seated in an erect position, with the head firmly placed against the wall or back of the chair, and let one eye be closed. Let another person take a seat in front of the first, and hold a pencil in one hand in a vertical position, within easy reach of the first person; then give the latter a pencil, and allow him to attempt to place the end of it on the end of the pencil that is held up, by holding his pencil in a vertical position, with its lower end a little higher than

the end of the pencil to be touched, and carrying it forward until he thinks it is immediately above the latter pencil, and then lowering it upon it. After it has been brought down at one time one or several inches in front, and perhaps at another time the same distance behind, and the amount of error has been readily detected, before removing the hand, by simply opening the other eye, the exactness that the new criterion, involved in the use of the two eyes, imparts to our estimate of distance will be fully appreciated. In performing the experiment it is generally advisable to hold up a newspaper, or other screen, between the parties, with one hand, with its upper edge but little lower than the top of the pencil to be touched, in order to conceal the arm and person, and eliminate any criteria of distance which might present themselves, other than that due to the use of two eyes, and which the experimenter might unconsciously employ.

Any criterion, of course, that enables us to estimate distances with so much ease and accuracy, will enable us to form very definite ideas of the forms of objects within its range, if applied to different points of the objects.

How distance is estimated, or this knowledge of a third dimensionis acquired by the use of two eyes, is, however, a matter of dispute, as well as whether it is done instinctively or by long experience.

Monocular Vision.

Before entering upon the discussion of this subject a very brief consideration of a few of the most familiar facts in connection with vision in general, besides affording a suitable introduction, and thread upon which to arrange facts subsequently, may result in economy of time.

In the representation of the human eye, Fig. 1, *gg* represents the optic nerve passing in from the brain, and expanding into a delicate, pulpy membrane, called the *retina*, upon the posterior portion of the interior of the eye ball. The other transparent refracting portions which make up the mass of the eye, viz., the *Aqueus humor*, W., the *Crystalline lens*, L., and

Vitreous humor, H., together equivalent to a convex lens, cause the pencils of light, emanating from the different points of an object to converge to corresponding points on the retina. Thus, those represented as diverging from A in the object are found, after entering the eye, to converge to the point *a*, those from B to *b*, from C to *c*, &c. Each point of an object would thus be found to have its representative on the retina, which together would form a perfect image of the external object. The operation can be traced no further. In some way, inexplicable to us, the optic nerve bridges over the chasm to the mind within, and over it the report of the image is made. It is, perhaps, allowable to say, that the rapid waves of imponderable ether, which constitute light, are felt by the delicate retina, just as truly as the impact of waves of the ponderable air, propagated through the beautiful accoustical combination of membrane, and bones, and liquid, is felt by the filaments of expanded auditory nerve floating in the liquid in the caverns of the ear, lying in wait as it were for indications of external objects, or just as truly as our cheeks feel the puffs of the wind and report them to us.

But whilst the effects of light cannot be traced further than the image on the retina, it has been ascertained that all portions of the retina do not report with equal distinctness, that, in fact, but a small portion, or but a spot, on the retina transmits its impression with the distinctness necessary for a clear perception of external objects, and that receding from this point,—called the *point of distinct vision* the portions of the image are reported with diminishing distinctness to the mind; therefore but one point of a body stared at can be seen distinctly, viz., that which has the rays diverging from it converged upon this point of the retina, or, since the line passing to this point through the centre of the eye, as well as the centre of the pupil, is called the *optic axis*, the fact can be stated that only that point of an object is seen distinctly which lies in the optic axis, or toward which the optic axis is directed. Thus, Fig. 1, the dotted line C *c* is the optic axis, and the point C alone would be distinctly seen. If the eye were immovable it would be necessary, in order to see the different points of an object distinctly, to turn the head, so that each point should, in turn, fall on the optic axis. But the eye has a horizontal play of 60 degrees towards the nose, and 90 degrees outward; the optic axis can, therefore, be very readily, practically instantaneously, directed upon the different points; and this is done unconsciously when an object appears to be seen distinctly at once.

This rapid, unconscious movement of the eye will be illustrated subsequently.

Binocular Vision.

But whilst with one eye an object can thus be very distinctly seen, and its *direction* also, it is evident, from the experiment previously described, that with two eyes there is a very decided advantage in forming an estimate of its distance and form, that a new, more decisive, criterion of distance is introduced. This new condition, under which the object is viewed, is the variation in the angle formed by the optic axes in observing distinctly nearer and more remote points. Thus, Fig. 2, when the point A is distinctly seen, the optic axes form

the angle p A p with each other; that the point B may be distinctly seen, the optic axes must be directed upon it, or the eyes must be rolled toward the nose until A p coincides with B p', or until the image of B occupies the point of distinct vision, p, occupied the instant before by that of A. Thus rapid, though unconscious, convergence of the optic axes upon many, if not all the points of a body, conveys to the mind the idea of distance, and reports of distance are as unconsciously translated into facts of form.

A painting or drawing may, by proper attention to perspective, shading, and other monocular criteria of distance, be made to produce quite an illusory effect, when viewed with one eye, but to both eyes it will seem flatter, and be felt to be less satisfactory. They will miss the varying binocular parallax that should accompany the varying distances represented. In proportion, however, as the other criteria of distance are faithfully introduced, this want of satisfactoriness to two eyes will be felt less, especially if range of distance lying beyond the limits of this criterion is represented.

A monocular view of an object cannot only be almost perfectly reproduced in a drawing, because perspective, shading &c., can be reproduced on a flat surface, but monocular vision for similar reasons is subject to many fallacies, by simple variation of the conditions under which an object is viewed. Thus it is frequently impossible to determine whether an object is a bas-relief or an intaglio, and it may be made to appear to be either by regulating the light falling on it. Every microscopist realizes this. In Letters on Natural Magic, by Brewster, many curious instances are given. The following interesting example is given in his treatise on the Stereoscope, p. 228, as follows :

"A very remarkable illusion, affecting the apparent position of geometrical solids, was first observed by the late Professor Neckar, of Geneva, who communicated it to me personally in 1832. 'The rhomboid A X, fig. 3,' he says, 'is drawn so that the solid angle A should be seen nearest to the spectator, and the solid angle X the farthest from him, and that the face A C B D should be the foremost, while the face X D C is behind. But in looking repeatedly at the same figure, you will perceive that at times the apparent position of the rhomboid is so changed that the solid angle X will appear the nearest, and the solid angle A the farthest, and that the face A C D B will recede behind the face X D C, which will come forward, which effect gives to the whole solid a quite contrary apparent inclination.'

Professor Neckar observed this change 'as well with one as with both eyes,' and he considered it as 'owing to an involuntary change in the adjustment of the eye for obtaining distinct vision. And that whenever the point of distinct vision on the retina was directed to the angle A, for instance, this angle, seen more distinctly than the other, was naturally supposed to be nearer and foremost, while the other angles seen indistinctly were supposed to be farther away and behind. The reverse took place when the point of distinct vision was brought to bear upon the angle X. What I have said of the solid angles (A & X) is equally true of the edges, these edges, upon which the axes of the eye, or the central hole of the retina, are directed will always appear forward ; so that now it seems to me certain that this lit-

tle, at first so puzzling, phenomenon depends upon the law of distinct vision.'" There is nothing particularly remarkable in this. Every one can recall many instances in which this two-fold character of monocular diagrams caused confusion in the early struggles through Euclid. All that seems to be shown is that the mere bounding lines of an object, as they appear to one eye, cannot give us an idea of its form. There is no doubt, however, that in most cases one of the forms represented will generally present itself at first glance rather than the other, and a very plausible explanation presents itself for it. In the diagram, fig. 4, designed to illustrate another fact subsequently,

Fig. 4.

if either set of squares, (best the right hand set, because they are further apart), is observed, one of them will appear to be nearer the observer, but by very little effort it may be made to recede, and the other to advance to the front. By uniting the adjacent corners of the set by lines, the squares much more readily assume either position, especially if but one eye is employed, because a monocular drawing will be completed. But generally, at first glance, that solid will appear to be represented in which the lower square forms the nearer face, and the reason seems in this case to be, and to apply equally to that cited by Professor Neckar, that the apparent inclination, as he terms it, is more natural or usual than that of the other solid, since it appears to rest upon one of its faces whilst the other, when the lower square seems to form the remoter face, does not appear to be supported in any way, In the rhomboid drawn by Professor Neckar, this difference of naturalness of position is not so great, though it might be made still less, and it seems on that account to have most readily attracted the attention. The employment of two eyes only complicates the experiment without changing its character, as it is likely that it only succeeds, when the attention is concentrated mainly on the view obtained by one eye. The diagram is also constructed to

illustrate the difference between the evidence of one eye and of both eyes. Leaving the explanation of the part the stereoscope plays for a future time, the diagram is so constructed that, when viewed by aid of that instrument, a solid shall appear having the upper square as its nearest face, although this, as before stated, is the solid with least natural position, and this solid, fixed in form and position, can alone be made to appear; no effort of the will or imagination, no introduction of the usual criteria that affect our estimate of distance or form, can affect or change it. [In order to get the best effect it is desirable to form a *black* line diagram similar to fig. 4. This can be most readily and accurately done by placing a card, of the size of an ordinary stereograph, beneath fig. 4, and making the corners of the squares by puncturing.]

CONTRIBUTIONS TO PHYSIOGRAPHIC AND DYNAMICAL GEOLOGY, INVOLVING THE DISCUSSION OF TERRESTRIAL MAGNETISM.

By Prof. Richard Owen, M. D., LL.D.*

In offering some new facts bearing on the above subject, perhaps it is admissible previously to call to mind a few established facts, particularly astronomical, which have more or less recently been promulgated.

1. That sometimes the earth's greatest proximity to the sun occurs in our winter, sometimes in our summer; thus about 4000 B.C. perihelion was on 20th Sept.; and A. D. 1864 perihelion was 1st Jan.

2. That the sun has at present more duration of power by seven or eight days in our combined spring and summer than in our combined autumn and winter; 850,000 years since, this difference amounted to fifteen days, giving the northern hemisphere relative advantage in land forming, if the magnetic law hereafter indicated is admitted.

3. Genl. Sabine found the dip to increase with the proximity of the earth to the sun, and *vice versa;* this proximity may coincide with our winter or with our summer; at present with the former.

4. The periodical change in the form of the earth's orbit from an ellipse to a figure almost circular, must further modify the proximity chiefly dependent upon the earth's place in her orbit.

5. We must bear in mind that the ecliptic, at one period, formed

*Read before the American Association for the Advancement of Science, Indianapolis, August, 1871.

an angle with the equator at least as small as 22½°, the fourth part of 90°.

6. Humboldt's objection to supposing currents of electricity to move around the earth, arose from his finding that solar heat did not penetrate any very considerable depth in the soil; but he himself suggests, since the discovery made by Faraday, of warm oxygen being diamagnetic, that the electrical currents may exist in the air. It will be shown afterwards that these probably move also along earth molecules, which arranged themselves parallel to the ecliptic during the consolidation of land.

7. Fourteen years since I demonstrated, in "Key to the Geology of the Globe," published in Nashville, Tenn., that most extra tropical continents, or extra-tropical parts of continents, exhibited coast lines and mountains having a general trend of 23½° east or west of the terrestrial poles; while intertropically the coast lines trend 23½° north or south of the equator.

In enumerating some recently observed facts carrying out more fully the above law, after testing it by many more coincident facts than the time usually allotted would permit me to set forth in detail, I shall confine myself to the most prominent, and arrange them under

I. Terrestrial Magnetism.

Perceiving that the coast lines of continents coincided with the Terminators of some phase of the ecliptic, and other portions in the interior of the V-shaped land, were marked by other secondaries of the ecliptic, while the central, straightest and most elongated were at right angles to the equator, it seemed impossible to avoid the conclusion that the sun had a more or less remote influence in giving form to the land.

It was soon, however, further observed that the greatest heat coincided with the solstices of certain phases of the ecliptic; that all the known localities of gems (generally supposed to result from crystallization under electrical influence) could be traced along two special phases of the ecliptic, and that the secondaries of these ecliptics marked very important coast and mountain lines, great circles of heat, chemical and volcanic action, &c. Also, that under some of these had been raised, within the historical period, large tracts of country as along the Andes and in Sweden and Finland; also Islands, as Reguain, Santorin, Graham's Island, &c., while other portions not under those lines were sinking, as Greenland north of Lat. 69° N. which is north of the Terminator.

All these and many other coincidences forced the conviction that the sun, at least at the solstitial periods, must by thermal difference generate currents of electricity, probably in the oxygen of the air and in the diamagnetic earth molecules. This would at once account, as Ampère showed, for the magnetic needle arranging itself at right angles to those currents, and if magnetism can expand the earth's crust, then we see why the land was elevated along the secondaries. But if it be denied that magnetic impulses are sufficient to produce these phenomena, then we have only to consider magnetism converted into its other phase, chemical action, with the development of gases, the fusion from solidity or the solution in hot water, of metallic and earthy ingredients, the expansive power not only of the gases, but of the other phase heat, transmitted to the yet inert masses, and we certainly have, as far as human eye can penetrate, in this subterranean laboratory, all the conditions fulfilled for bringing about the effect we observe on the surface.

If, then, we admit magnetic phenomena as modifying directly or indirectly the earth's structure, we are next led to inquire what peculiar modifications are connected with the magnetic phases of Intensity, Dip and Variation. These will be briefly alluded to in the above order:

Intensity.—A great circle passing close to the coast of Brazil passes through one of the foci of intensity as laid down by Mrs. Somerville, and continued into the opposite South Pacific, passes also through, or close to, the focus of greatest intensity as laid down by Humboldt and Mrs. Somerville. If we construct an ecliptic which shall have its solstices immediately north and south of this weaker South Atlantic focus, we have an ecleptic, which especially during our winter, when perhaps that season coincided with perihelion, exhibits great intensity and electrical power, either residuary from a former period, or now existing, as indicated by the foci of its secondary, or perhaps both combined. To prove this, let us trace it through Brazil, where the emeralds and diamonds are found, next near Cape Comerin and Ceylon, the region of diamonds and sapphires, to the ruby locality between Birmah and Siam. The only other noted gem localities can be found under, or near, an ecliptic of next greatest intensity, whose solstices are found due north and south of the centre of land, centre of motion and evidently centre of the whole magnetic system. It traverses, if we follow *both* semi-annual declinations, the

diamond regions of Brazil, South Africa and of India, and embraces between its converging lines the diamond region of Borneo.

The secondaries for the solstices of maximum intensity arise respectively from nodes on the equator just east of Africa and north-east of the Marquesas. The former, which are the stronger, define the north-east coast of Africa along the Red Sea, through Hungary and Prussia to Iceland and Greenland, where its east coast intersects the arctic circle. This is exactly 90° from both the nodes just spoken of, for which reason, and because it is antipodal to Sir J. Ross' Mag. S. Pole, but more especially because all the seventy-four observations for declination laid down around the globe (as given in Lard. Nat. Phil., p. 208,) converge in their variation to this point, except a few drawn aside by the magnetic pole of dip, we must consider the Greenland Arctic Pole as the pole of greatest intensity. This terminator further passes through the Hudson Bay focus of intensity, while its mate passes through the Siberian focus. Intensity thus appears due to combined proximity of the sun and greatest solstitial power.

Dip.—If we trace the equator of dip according to the best authorities, it is found to undulate between the two ecliptics just described, and to intersect them where they intersect each other, vertically in the Western Hemisphere, under Sir J. Ross' North Pole of dip, in the Eastern Hemisphere due south of the Gulf of Obi, in which, about lat. 70 N., there seems, as was suggested by Hansteen, to be an Asiatic North Pole of dip, and, I may add, perhaps also an Asiatic North Pole of intensity on the arctic circle 180° from Greenland. These have probably South Poles; indeed the antipode of the Gulf of Obi is laid down in Humboldt as a point indicated by Ross as having magnetic importance (see Vol. IV Cosmos, Longman's, Edit. p. 97). Dip, then, seems that phase of magnetism connected with equilibrium, between the ecliptics of intensity, perhaps between perihelion in our winter and perihelion in our summer.

Variation or Declination.—The whole magnetic system is known to move slowly and periodically; at present that movement is from west to east in the northern hemisphere, while in the southern the motion is from east to west.

If we consider the African node, where the centre of motion, centre of dip, and centre of land and solstitial meridian of intensity No. 2 all intersect, as the centre, also, of magnetic oscillation, and permit the secondaries to vibrate to their supposed extremes, viz. 16½° each side of the terrestrial North Pole, we find the western secondary

following important coast lines, and not only passing through the Greenland pole of intensity, but through the Boothia Felix pole of dip and the South Pole of intensity. Trace now the eastern secondary and we find it marking the Gulf of Obi pole and its antipodes, besides slightly deflecting the northern part of the Ural Mountains, which in the rest of their course conform to an equinoctial secondary; being directly over the east African node of ecliptic intensity No. 1. The variations for Paris, taken from A. D. 1580 to 1835, as given by Lardner, p. 210, are measurably accounted for on the supposition of this oscillation occupying perhaps 300 years or thereby, while the intensity vibrates or changes from the one secondary to the other, in accordance with the predominance of electricity in one ecliptic or the other; the dip, however, varying also in connection with perihelion and aphelion.

Horary and Semi-annual Variations in Declination.—If strong additional evidence were required to show that the sun's electricity caused the position of the needle, it is found in the two facts: 1, that the needle every day has a slight variation from soon after average sunrise to soon after his reaching the meridian of any given locality; the currents evidently approaching the needle in a somewhat different plane, as modified by refraction or other causes, from the plane assumed at noon; and that there should be slight reaction in the afternoon, when the warmer molecules are *west* of the colder instead of being east of them, seems natural. 2. The second is that the needle besides varies six months in one direction and, changing at the equinoxes, exhibits its variations for six months in the other direction; that the semi-annual variations in declination should be different in the northern and southern hemisphere and change at the equinoxes, is readily understood; but why St. Helena, in about 15° S. lat., and Singapore, about 2° north of the equator, should partake half the year of the perturbations peculiar to the northern hemisphere, and during the other six months of perturbations peculiar to the southern hemisphere, was not comprehended; it is, however, at once explained when we observe that the former place is situated on the intensity ecliptic No. 1—the other on intensity ecliptic No. 2.

Disturbance Variation.—As there is a residuary power in the paramagnetic molecules (which in the Rocky Mountains prevents the use of the magnetic needle, and compels the employment of Burt's solar compass) and as the direction of magnetic impulses would be north north-west in the Rocky Mountains, while in the Appalachians, or even

at Toronto, it would be north north-east, although both sets of impulses start from near Chimborazo, it is easily seen why, as Point Barrow is near one secondary and Toronto near the diverging secondary of the other solstice, the so-called disturbance variation, although occurring simultaneously, should yet have opposite phases.

Agonic Lines.—There is no variation at all points centrally between these diverging secondaries, namely: along the secondaries of the equator; the needle, setting itself at right angles to the equinoctial plane, points to the terrestrial north and south pole. These agonic lines occur chiefly at the meridians of the ecliptic nodes, but are found more or less every 45° east and west of the west African node, which may be termed the prime magnetic meridian.

11. Geology and Physical Geography.—The facts, recently observed, bearing on this second sub-division of the subject are chiefly these:

Along the ecliptics prevail mostly those chemical effects such as the crystallization of carbon into diamonds, &c., as well as regions of greatest heat, and the upheaval of the second highest mountains; while along the secondaries we find abundant evidence also of heat at the geysers, linear hot springs, linear volcanoes, Gulf and Japan streams, &c., as well as chemical action in erupted molten rocks, liquid mud, gases and the like; and also mark the rise of the Himalayas.

The divergence of two terminators south-west of South America seems the probable cause why the tidal wave, instead of entirely following the moon, here separates. The heat of the Scandinavian terminator may account for the melting of the icebergs and the dispersion of drift from that region, and the activity of the geysers in Iceland; while a secondary of the other ecliptic has given warmth to the region of the Lena.

Vital energy seems to have been imparted to vegetable and animal life by the magnetic impulses, chiefly of these solstitial secondaries, as near them we find the giant Sequoias, the ancient monsters of Nebraska, of the Pampas Plains, of Siberia and the Urals.

The land on the globe is to the water as 66 or 67 to 180 (the former without the Antarctic continent), and in accumulating in the northern hemisphere (probably because proximity agreed with our winter intensity when paleozoic land was forming during the prevalence of intensity ecliptic No. 1), it has extended itself chiefly from the Tropic of Cancer to the Arctic region. Africa forms an excep

tion, for that continent has accumulated as land around the central intersection of the terrestrial and dip equator in such manner that the Mediterranean is nearly 33° north of the node, and the Cape of Good Hope is a somewhat greater distance south, together 66° or 66½°, while the width of Africa, from Cape Verde to Cape Gardafui, is also 66°. The length of North America and of South America, as well as of Asia, from her northern Shore to Cape Comerin, also measures 66°; indeed the length and breadth of all land is found to be some dividend of that number.

Sixty-six and a half degrees being the complement of the ecliptical angle, or, in other words, this being the angle which the earth's axis forms with the plane of the equator, the land would naturally assume those dimensions, as well as the rhomboidal shape which several continents have, with the acuter angles pointing north and south, if the sun caused its development. As an interesting corroboration of this law, that the sun gives form and dimensions to the land, let us take with compasses the distance from Cape Comerin (where the greater intensity ecliptic is found) to the north coast of Asia, and moving one foot of the compasses thus extended along the north coast, either east or west, the other foot will be found to correspond to one or other ecliptic. This appears to indicate that the magnetic effect is powerful about 66½° north of the electrical current, inducing strong terrestrial magnetism at that distance, although the poles are 90° from the equator, measuring on the secondaries.

The chief deposits of the paramagnetic metals, especially when nearly or quite pure, connect north and south, while those of some diamagnetic metals, gold at least, can be traced along parallels of latitude. Time has not permitted a full investigation of this practically useful branch; but I may mention that, while the chief deposits of coal are found along or parallel to the solstitial secondaries, those of petroleum and bitumen are near those (and perhaps across one, as in Pennsylvania), but are connected by lines which are secondaries to the equinoctial plane, such as the great circle passing from New York and Pennsylvania through Virginia and North Carolina, Cuba and Jamaica, New Granada, Burmah, Lake Baikal, &c. Trinidad, however, is nearly under an ecliptic, and the Baltic, where amber is common, under one of its secondaries. The Caspian Sea bitumen is under an equinoctial secondary.

We must now, reserving further details for future discussion, hasten to the

SUMMARY.

A vast number of coincidences are fully explained, if we admit the law that solar influence indirectly has caused the phenomena to which Humboldt in his immortal Cosmos gave the name "Reaction of the interior of the earth on its exterior." Add to this the fact that the whole is strictly in accordance with the correlation of forces, and throws much light on the hitherto unexplained phases of Terrestrial Magnetism.

Much, then, as theorizing is sometimes to be reprehended, and generalization without sufficient facts is to be condemned, probably every scientific man will agree that (as here no favorite theory was started with, to which some facts were made to bend while anomalies were set aside, but facts were collated until they pointed to a law) we are justified in following up this interesting glimpse into the arcana of nature, and in admitting as a general law that which embraces the whole array of coincident facts, beautifully explaining many phenomena, and pointing us to the conclusion which every year, as science advances, is more powerfully set forth to our observing and reflecting faculties, that there is uniformity and simplicity in the great plan of creation.

If the law is admitted, it would bring us to something like the subjoined conclusions:

1. The sun is the source of the modifications on the earth giving the form and dimensions of the land; operating through some of the phases, or modes, of motion, which we embrace under the names light, heat, electricity, magnetism, vital force, and probably nervous energy.

2. By thermal difference, ecliptical and equatorial currents are generated chiefly from east to west, from the hotter air and earth molecules to the cooler, each afternoon, however, producing a slight reaction, on the same principle.

3. These currents generate magnetism at right angles to themselves, viz., along the secondaries of the ecliptic in all its phases, although most strongly at those of the solstices, and also along the secondaries of the equator, which are meridians, especially at every 45° apart, beginning east and west, from the prime magnetic meridian.

4. The electricity of the ecliptics has produced heat and crystallization, and offers an explanation of the Zodiacal Light; while the magnetism of these secondaries, either directly or by conversion into chemical force, has developed the land, called forth the metals, stirred the volcanoes into activity, heated the Geysers, the ocean currents

and the hot springs, modified the climate at different meridians on the same parallels, caused the tidal wave to diverge, perhaps melted the glacier ice that held the Drift boulders, accounts for the Aurora-borealis and australis, stimulated vegetation, and gave energy to animal life.

A field is thus opened for further investigation, which pertains not to the Geological and Mining Engineer alone, however important to them, but offers labor full of interest for the Astronomer, in defining accurately the modifying periods of greatest heat, light, electricity, magnetism, &c., in connection with the precession of the equinoxes, proximity of the sun, solar spots, form of the earth's orbit, &c.; for the Physicist, in confirming and classifying the observations connected with terrestrial magnetism; for the Physical Geographer, in tracing his orology, courses of rivers, winds, currents, electrical and seismographic phenomena, also the distribution of plants and animals, as well as the distribution of heat and rain, pursuing these researches with hereby increased light and vigor; while to the Naturalist, the Anthropologist and Historian, or Student of the Philosophy of History, there is furnished ample food for reflection.

Finally, above all, these sublime developments should stimulate us all with fresh desire to understand more fully the beautiful and immutable laws by which the Divine Ruler holds the universe in harmonious action, and should cause us to increase our endeavors ever to live in accordance with those divine laws.

SIGNAL SERVICE WEATHER REPORTS.

By Pliny Earle Chase,
Professor of Physics in Haverford College.

The recent instructive articles upon the Signal Service Bureau, in Scribner's and Harper's Magazines and the "American Journal of Science," have by no means exhausted the interest which attaches to the weather bulletins. Without much trespass on the ground which others have so well covered, I will endeavor to present to the readers of the *Journal* some details which I hope will prove acceptable, for a large portion of which I am indebted to the courtesy of Prof. Cleveland Abbe, the accomplished astronomer and meteorologist, to whose skill we owe the successful daily forecasts.

Dr. Franklin's demonstration of the identity of atmospheric and

frictional electricity, and his discovery of the customary travel of storms toward the northeast, the distribution of instruments and instructions to observers by the Franklin Institute, Dr. Emerson's observation that a great rise of the barometer often belies its stereotyped prediction of "Set Fair" by preluding a northeasterly storm, the invaluable generalizations of Redfield and Espy, Ferrell's exhaustive mathematical analysis of "the motions of fluids and solids on the surface of the earth," Blodget's Climatology of the United States, Loomis's treatise on Meteorology, Coffin's Winds of the Northern Hemisphere and his tabulation of the observations of the indefatigable corps organized by the venerable Secretary of the Smithsonian Institution, Professor Henry's various physical, and especially his electrical, thermal and hyetal researches, Bache's Girard College Observations and Schott's discussion of the magnetic results, are but a portion of the contributions of American students to what might almost be regarded as the American Science of Meteorology.

Foreign meteorologists have not been backward in recognizing and acknowledging their indebtedness to American researches and suggestions, and few of them are so sanguine as to hope for a long maintenance of the accidental precedence, in successful applications of weather telegraphy, which they gained in consequence of the interruption of most branches of scientific labor by our civil war. Our territory, stretching across an entire continent in the normal pathway of storms,—the extensive plains of the Mississippi and Missouri valleys, furnishing peculiar opportunities for the blending of polar and equatorial currents,—our popular government, untrammeled by the exhausting exactions of monarchical power and huge standing armies, and therefore better able to grant the appropriations which are requisite for the support of an efficient corps of observers,—and the happy thought of military organization and responsibility, which Gen. Albert J. Myer, the chief signal officer, has so successfully carried out,—are advantages which may reasonably make us hopeful of tracking the wind, which "bloweth where it listeth," with unprecedented, if not with incredible success.

The hours appointed for the regular observations at each of the fifty-six subordinate stations are $7^h\ 35^m$ A. M., $4^h\ 35^m$ P. M., and $11^h\ 35^m$ P. M., Washington mean time. These hours were fixed upon because there were no others which would divide the day into three so nearly equal portions, and at the same time find the telegraph so free from other business. A system of circuits is specially arranged for

the office: 1, from Washington to New Orleans; 2, from Washington to New York; 3, from Washington to Chicago and San Francisco; 4, from Washington to Lake City; and all the subordinate circuits run into one of these four main stems. The whole line of wires of the Western Union Co., and of the Franklin, in case of the failure of the Western Union, is at the disposal of the Signal Office at the hours above stated. Each observer has an exact minute for starting his observations to Washington, sending them through such cities as desire to receive the report, Key West, for example, sending its despatches through Mobile, New Orleans, etc. These arrangements are made with a view to the greatest possible economy, and the charges are far below the ordinary rates for telegraphing. Montreal and a system of circuits from Canada have lately been added to the list of communicating offices, the legislature of the Dominion having voted the necessary appropriations.

The regular dispatch from each station consists of four lines of cipher, with five figures in each line. These figures are appropriated as follows:

Line 1.—Height of barometer, 3 figures; number of station, 2 figures.

Line 2.—Height of thermometer, 2 figures; relative humidity, 2 figures; direction of wind, 1 figure.

Line 3.—Velocity of wind, 2 figures; date, 2 figures; state of weather, 1 figure.

Line 4.—Upper clouds, 1 figure; lower clouds, 1 figure; rain fall, 3 figures.

The economy and simplicity of this arrangement may be readily shown by a single example:

0	1	2	5	6
6	2	7	7	8
0	2	1	4	1
2	0	0	0	0

The "Key" furnishes the following interpretation: "Barometer, 30·12 inches; Station, 56 = Montreal; Thermometer, 62°; Relative Humidity, 77 per cent.; Wind, 8 = N. W.; Velocity of wind, 2 miles per hour; Date, August 14; Weather, 1 = Fair; Sky, 2 eighths covered with cirrus clouds; Lower clouds, 0; No rain since last report."

The messages are sent in unbroken succession from the consecutive stations, the operator noting upon each sheet of figures the time when it was received. The division of the columns into four-line groups is made in the office, and the items are transferred, 1, to the manifold bulletin; 2, to the bed-plate for printing the daily maps; 3, to the map for official study, on which the isobaric lines (lines of equal barometric pressure) are drawn, and any notes or remarks are written which may facilitate forecasts.

In addition to the observations for telegraphic transmission, others are taken at the customary local hours, 7 A. M., and 2 and 9 P. M. These are entered on "Form 4" of the printed blanks, under the following heads: "Date of observation; Time of observation; Height of barometer; Height of attached thermometer; Height of exposed thermometer; Reduced barometer; Hygrometer (open air), Dry bulb, Wet bulb; Relative humidity; Direction of wind; Velocity of wind in miles per hour; Daily velocity of wind; Pressure of wind, lbs. per square foot; Amount of cloud; Direction in which upper clouds move; Rain (or snow) commenced (Time); Rain (or snow) ended (Time); Amount of rain or melted snow; Remarks." The sheets containing these entries are forwarded weekly, by mail, to Washington, together with copies of the daily telegrams as checks on the telegraphic reports.

When the returns from about half the stations have been received Prof. Abbe and his assistants commence a detailed synopsis, noting especially the changes in the barometer and thermometer, whether stationary, rising or falling, the direction of the wind, state of the weather and moisture of the atmosphere. From this synopsis the estimate of probabilities is made and a decision is formed as to the proper signals to be displayed, on the lake shores and the Atlantic and Gulf coasts, for the benefit of commerce. Press reports are also prepared, dated 10 A. M., 7. P. M. and 1 A. M., which are at once given to the agents of the Associated Press, and telegraphed by them to all their correspondents. The Bureau forwards the reports, at its own expense, to a few points which are not reached by the Associated Press.

In making the estimates it is necessary to bear continually in mind the general principles of pneumatics and hydrodynamics, and especially the laws developed in Ferrel's treatise, to which I have already referred. The following rule is of great service: "Stand with your left hand toward the place where the barometrical reading is lowest,

and your right hand toward that where it is highest, and you will have your back to the direction of the wind which will blow during the day." This is generally known as Buys Ballot's law, having been empirically deduced by Prof. Buys Ballot, of Utrecht, apparently without knowing that he had been anticipated by the purely theoretical reasoning of Ferrel. Capt Toynbee, of the British Meteorological Office, proposes to substitute for the places of highest and lowest barometer those where there has been the greatest rise and fall during the previous day, in order to judge of the direction toward which the wind is tending, and his modification often furnishes results of considerable value.

Since storms are the culminations of atmospheric disturbance, it is natural to look for them where such disturbance is greatest, either on the borders of the greatest barometric elevation, or at the centres of greatest depression. In estimating differences of pressure, and consequent wind producing force, "barometric gradients" are used which are customarily expressed in hundredths of an inch of mercury per fifty geographical miles. For example, if the barometer at Philadelphia stands at 30, while the one at Fortress Monroe stands at 29·50 inches, the distance being about 200, or 4×50 geographical miles, the gradient is $50 \div 4$, or 12·5. The best meteorological manuals give a variety of empirical rules, which have been deduced by Prof. Dove and others, for interpreting the indications of the barometer under various conditions of temperature, moisture, wind and season, which add greatly to its value as a guide for forecasts.

The temperature is invariably elevated upon one side of an area of low or high pressure and depressed on the other, and it is generally warmer in advance of any storm centre and colder in the rear. In forming estimates, if due regard is paid to the elevation, latitude and physical surroundings of the station, the thermometric indications of rising and falling temperature are valuable auxiliaries.

The humidity is large in advance of storm centres, and small in their rear. Increasing humidity is, therefore, an intimation of an approaching storm; decreasing humidity, of clearing-up weather. The more moist the air the greater will be the effect of a general diminution of pressure or temperature in inducing rain.

A "backing" wind is a well known sign of unsettled weather; a "veering" wind, or one which shifts with the sun, is an indication of fair weather. Within areas of high pressure the winds blow from the centre; in areas of low pressure, towards the centre; in either

case they are deflected towards the right hand as they move forward. Backing currents, or currents which, in the northern hemisphere, move in a direction opposite to that of the hands of a watch, are called cyclones, or cyclonic; veering currents are termed anticyclones, or anticyclonic. The backing or veering of the currents should not, however, be confounded with the shifting of the wind, which is determined by the directions in which the centre of the area of disturbed pressure lies and is moving. Hurricanes, the Chinese "great-winds" or typhoons, and the most sudden and violent storms, are cyclonic. It is often said that all storms are cyclonic, and even that all winds have a cyclonic origin, both of which statements are incorrect. The prevailing currents in the United States are anti-cyclonic, those in Western Europe cyclonic. Anti-cyclonic storms occur on both continents, but more often in America than in Europe. One of the surest indications of the approach of a storm to our southern and south-eastern coasts is the cyclonism of the winds in that region. Cyclones, in our hemisphere, tend to move northward, anti-cyclones southward.

The clouds, by their forms, changes and motions, indicate the relative temperature, moisture, pressure and direction of upper currents. The dependence of rain upon the meeting and blending of warm and moist with cooler bodies of air, is shown by the prevalence of two layers of cloud in stormy regions, the upper stretching far in advance of the lower, but descending and joining it in the rear of the area over which rain is falling. The "stratus" or "layer" clouds are generally reported in connection with threatening weather at the different stations, and the higher and more fleecy—"cirro-stratus"—usually precede the storm clouds at some distance.

The general movement of the areas of stormy and clear weather, high and low pressure, warm and cold temperature, moist and dry air, is eastward, over the larger portion of our territory, with velocities ranging from one to fifty, and probably averaging less than thirty miles per hour. This movement, which is controlled by the flow of the upper atmosphere, and is most uniform in winter, greatly facilitates predictions of the progress of storms from the Rocky Mountains to the Atlantic seaboard, and a careful observation of the areas of greatest humidity most favorable to rapid condensation will suggest probable sinuosities in their track. The more violent winds generally follow in the rear of the area of lowest pressure, but those

which precede that area may often be more dangerous, on account of the accompanying rain, snow, mist or fog.

As a typical illustration of the ease with which our ordinary winter storms can be traced, Prof. Maury refers to the reports of February last. On Feb. 21st, in the midnight report, the commencement of a storm was announced at San Francisco. Its progress was followed from bulletin to bulletin, until it reached the Atlantic coast. On the 23d, at 4h. 35m. P. M., the announcement was made: "it is probable that the storm predicted for to-day will soon reach Lake Michigan, where clouds and brisk winds now prevail." It made its appearance on the lake on the morning of the 24th, when the office again successfully predicted that it would "move north-eastward, with comparatively little rain or snow except in Canada, and southerly winds with rain from Cape Hatteras to Maine."

One of the most important hydrodynamic principles is the tendency towards equilibrium. The alternations of solar heat and nocturnal radiation, modified by the different capacities of mountains, forests, deserts, lakes and oceans for absorbing and retaining warmth and moisture, are continually disturbing the atmospheric equilibrium, and the problem of the weather-seer is to judge, from the actual conditions at any moment, what must take place to restore the normal condition of a given place or region, for a given day or season. For this purpose, tables and charts, constructed from the averages of long series of observations, such as are given in Coffin's "Winds of the Northern Hemisphere," and in Buchan's article on the mean pressure of the atmosphere (Edinburg Transactions, vol. xxv. Art. xvii), are of great service. Buchan's diagrams of monthly isobaric lines, although based upon comparatively meagre observations, are the best guide yet published to the equilibrating forces which are constantly struggling against the disturbances. The signal office is collecting an immense amount of observations, with the view of preparing similar charts specially fitted for American use, and it is also investigating various laws of local disturbance, which will eventually be published, so as to be practically available.

There has been a very general impression that it would be much more difficult to anticipate the storms in summer than in winter. There is undoubtedly a greater variety of disturbances during hot weather, and it is impossible to track the commotions which come to us from the Atlantic, for so great a distance as those from the Pacific. But difficulty is always a stimulus to ingenuity, and the degree of

success, which has attended the summer work of the office has been most gratifying.

From the 2d to the 4th of June a storm passed from Key West through the centre of the Gulf of Mexico, the daily bulletins signalling its progress. The cyclonic winds in the Gulf States gave notice of its approach, and the office accordingly issued the warning on the morning of the 2d, "it is probable that the high winds in the Gulf will advance with rain to the coast of Louisiana." A heavy storm swept with great damage over Louisiana and Galveston, from the morning of June 3d, to the evening of June 4th. The approach of a damaging storm, heralded by similar indications, to the coasts of Florida, Georgia and South Carolina, was shown by the bulletin of 1 A. M. on Aug. 16th, and its progress duly reported for the four following days, until it had "moved north eastward, beyond the cognizance of our stations."

One of the most important generalizations which may be regarded as almost conclusively established, is the fact that the summer storms and tornadoes appear simultaneously over well defined regions of falling or low barometer, and never over districts of rising or higher barometer. Several cases have occurred of areas of low barometer advancing from San Francisco with pleasant weather, and producing a storm upon arrival at the lakes.

The disturbances in the upper atmosphere more frequently pervade the whole mass in winter than in summer, producing wide-spread storms. Similar disturbances, when the thin lower stratum of heated air at the earth's surface presents the proper conditions of penetrability, may produce numerous local storm-eddies in summer, in the subjacent area which would have been involved in a general storm if it had been winter. In winter, areas of low barometer stretch out towards the lakes oftener than in any other direction, a fact which is generally attributed to the moisture of the air over the lakes. Prof. Abbe thinks that precipitation, which is oftener shown in the form of cloud than in the form of rain, accounts for the phenomenon more satisfactorily than the mere presence of moisture. The greater persistence of low pressure in the lake region than elsewhere during summer, is perhaps more especially attributable to the solar heat which produces, at that season, a normal region of low barometer in the British Provinces, similar to the one in the interior of Asia. In each of those districts there is normal high barometer during winter.

There are, on the other hand, some districts in which the persistence of high barometer during summer is very striking. They are, perhaps, more frequent in the neighborhood and west of mountain ranges, in Western Pennsylvania for example, as if the air, in its eastward flow, were compressed by the resistance it encountered in traversing the ridge. From the 15th to the 18th of July last, the barometer had been steadily ascending from Western Virginia to Massachusetts. On the 18th, the dense air suddenly poured over the mountains, driving a small but severe storm on to the coasts of New Jersey. This storm was wholly exceptional in the experience of the office, and it therefore came without any official warning.

The haziness of summer and autumn, especially of "Indian summer," have often been attributed to burning prairies, but many have been skeptical as to the possibility of a local fire kindling so "great a matter." During the past few weeks the observers have been able partially to remove this doubt. From the 12th of August, the bulletins, for several days in succession, announced a dense smoke at Detroit, sufficient to impede navigation on Lake Huron. Much of it came from burning woods in upper Michigan, some of it from the woods east of Lake Huron. The smell and haze gradually spread south-eastward as far as Maryland, furnishing indications of the direction of the upper atmospheric currents, and operators at Oswego and other stations eastward or north-eastward, also reported "dense smoke" or haze.

Eager Olivers, "asking for more," already solicit predictions for two or more days in advance. If the forecasts for a single day were infallible, they might be used as the basis for new ones, and so on indefinitely. But if the first forecasts prove true in only three cases out of four, those based upon them would be probably correct in only nine cases out of sixteen, which is little better than a random guess. Still we may hope that the tabulations and discussions in which the office is now engaged, the Smithsonian investigations of annual and secular rainfall which are now in press, and the study of meteorological records by groupings in lunar and planetary periods, will ere long warrant bolder undertakings. Until some safe basis for more extended forecasts has been found and tested, let us be thankfully content with our present daily announcement of "probabilities," which, even if it does not fully satisfy the most sanguine longings, is far beyond anything that could have been reasonably anticipated from so brief and limited experience.

Use of Bromine in place of Chlorine in Analysis.*—It will be of interest to those engaged in the laboratory, to know that the substitution of bromine water for chlorine is highly recommended by H. Kämmerer; who, after using the process, claims for it several advantages.

The use of chlorine in the precipitation of manganese, the detection of nickel with cobalt, in the separation of arsenic, &c., is attended with a great inconvenience from the extreme decomposibility of the reagent and the frequent unpleasant necessity of preparing it anew; while bromine is free from this objection, inasmuch as it can be prepared in a few minutes whenever needed.

The author informs us that in all cases where the use of the reagent depends on the formation of a hypobromite, the action is far more energetic than with chlorine.

The detection of nickel in presence of cobalt, in cyanide of potassium solution, by the process of Liebig, often fails when old or weak chlorine is used; while on the other hand, the author assures us bromine never fails of success.

Bibliographical Notices.

The Claims of the Academy of Natural Sciences of Philadelphia to Popular Favor. By W. S. W. Ruschenberger.

This pamphlet, from the pen of the Academy's President, contains, besides a running history of this honored Society, a strong statement of its urgent wants, and an appeal to the intelligent public, who are indebted to it for so many days of interest and instruction, for aid in placing the Institution in a position where its activity and usefulness will not be trammelled for want of means.

It should be a matter of pride to our citizens to place the magnificent and, in certain departments, unsurpassed collections of the Academy in a building where they would be safe from the possibility of destruction by fire, and it is certainly a matter of regret to us that good cause should have existed to have made the publication of the pamphlet necessary.

* Ber. d. Deutch. Chem. Gessel. iv. 218.